Homework 4: Functions, Histograms, and Groups

Reading:

- Visualizing Numerical Distributions (https://www.inferentialthinking.com/chapters/07/2/visualizing-numerical-distributions.html)
- Functions and Tables (https://www.inferentialthinking.com/chapters/08/functions-and-tables.html)

Please complete this notebook by filling in the cells provided. Before you begin, execute the following cell to load the provided tests. Each time you start your server, you will need to execute this cell again to load the tests.

Homework 4 is due Thursday, 2/20 at 11:59pm. Start early so that you can come to office hours if you're stuck. Check the website for the office hours schedule. You will receive an early submission bonus point if you turn in your final submission by Wednesday, 2/19 at 11:59pm. Late work will not be accepted as per the policies (http://data8.org/sp20/policies.html) of this course.

Throughout this homework and all future ones, please be sure to not re-assign variables throughout the notebook! For example, if you use `max_temperature` in your answer to one question, do not reassign it later on. Moreover, please be sure to only put your written answers in the provided cells.

In [1]:
```
# Don't change this cell; just run it.

import numpy as np
from datascience import *

# These lines do some fancy plotting magic.\n",
import matplotlib
%matplotlib inline
import matplotlib.pyplot as plt
plt.style.use('fivethirtyeight')

from client.api.notebook import Notebook
ok = Notebook('hw04.ok')
```

```
=====================================================================
Assignment: Homework 4: Functions, Histograms, and Groups
OK, version v1.14.19
=====================================================================
-----------------------------------------------------------------------
----
LoadingException                          Traceback (most recent call l
ast)
<ipython-input-1-00bc98324850> in <module>
     11 
     12 from client.api.notebook import Notebook
---> 13 ok = Notebook('hw04.ok')

/opt/anaconda3/lib/python3.7/site-packages/client/api/notebook.py in __
init__(self, filepath, cmd_args, debug, mode)
     13         ok_logger = logging.getLogger('client')   # Get top-lev
el ok logger
     14         ok_logger.setLevel(logging.DEBUG if debug else logging.
ERROR)
---> 15         self.assignment = load_assignment(filepath, cmd_args)
     16         # Attempt a login with enviornment based tokens
     17         login_with_env(self.assignment)

/opt/anaconda3/lib/python3.7/site-packages/client/api/assignment.py in
load_assignment(filepath, cmd_args)
     22     if cmd_args is None:
     23         cmd_args = Settings()
---> 24     return Assignment(cmd_args, **config)
     25 
     26 def _get_config(config):

/opt/anaconda3/lib/python3.7/site-packages/client/sources/common/core.p
y in __call__(cls, *args, **kargs)
    185                 raise ex.SerializeException('__init__() missing
expected '
    186                                 'argument {}'.format(attr))
--> 187         obj.post_instantiation()
    188         return obj
    189 

/opt/anaconda3/lib/python3.7/site-packages/client/api/assignment.py in
post_instantiation(self)
    151     def post_instantiation(self):
    152         self._print_header()
--> 153         self._load_tests()
    154         self._load_protocols()
    155         self.specified_tests = self._resolve_specified_tests(

/opt/anaconda3/lib/python3.7/site-packages/client/api/assignment.py in
_load_tests(self)
    205 
    206         if not self.test_map:
--> 207             raise ex.LoadingException('No tests loaded')
    208 
    209     def dump_tests(self):

LoadingException: No tests loaded
```

Before continuing the assignment, select "Save and Checkpoint" in the File menu and then execute the submit cell below. The result will contain a link that you can use to check that your assignment has been submitted successfully. If you submit more than once before the deadline, we will only grade your final submission. If you mistakenly submit the wrong one, you can head to okpy.org and flag the correct version. There will be another submit cell at the end of the assignment when you finish!

```
In [2]: _ = ok.submit()
```

```
---------------------------------------------------------------------------
----
NameError                                 Traceback (most recent call l
ast)
<ipython-input-2-cc46ca874451> in <module>
----> 1 _ = ok.submit()

NameError: name 'ok' is not defined
```

Burrito-ful San Diego

Tam, Margaret and Winifred are trying to use Data Science to find the best burritos in San Diego! Their friends Irene and Maya provided them with two comprehensive datasets on many burrito establishments in the San Diego area taken from (and cleaned from): https://www.kaggle.com/srcole/burritos-in-san-diego/data (https://www.kaggle.com/srcole/burritos-in-san-diego/data)

The following cell reads in a table called `ratings` which contains names of burrito restaurants, their Yelp rating, Google rating, as well as their Overall rating. It also reads in a table called `burritos_types` which contains names of burrito restaurants, their menu items, and the cost of the respective menu item at the restaurant.

In [3]:
```
#Just run this cell
ratings = Table.read_table("ratings.csv")
ratings.show(5)
burritos_types = Table.read_table("burritos_types.csv")
burritos_types.show(5)
```

Name	Yelp	Google	Overall
Albertacos	3.5	3.9	3.45
Burrito Factory	4.5	4.8	3.5
Burros and Fries	3.5	4.1	3.575
Caliente Mexican Food	3.5	4.4	3.25
California Burrito Company	3.5	4.4	3.2

... (77 rows omitted)

Name	Menu_Item	Cost
Albertacos	California	5.7
Albertacos	Carne asada	5.25
Alberto's 623 N Escondido Blvd, Escondido, CA 92025	Carne Asada	4.59
Burrito Box	Steak with guacamole	11.5
Burrito Factory	Steak everything	7.35

... (244 rows omitted)

Question 1. It would be easier if we could combine the information in both tables. Assign `burritos` to the result of joining the two tables together.

Note: it doesn't matter which table you put in as the argument to the table method, either order will work for the autograder tests.

Hint: If you need refreshers on table methods, look at the python reference (http://data8.org/sp20/python-reference.html).

```
BEGIN QUESTION
name: q1_1
```

In [4]:
```
burritos = burritos_types.join("Name", ratings) #SOLUTION
burritos.show(5)
```

Name	Menu_Item	Cost	Yelp	Google	Overall
Albertacos	California	5.7	3.5	3.9	3.45
Albertacos	Carne asada	5.25	3.5	3.9	3.45
Burrito Factory	Steak everything	7.35	4.5	4.8	3.5
Burros and Fries	California	7.19	3.5	4.1	3.575
Burros and Fries	Carne asada	6.89	3.5	4.1	3.575

... (207 rows omitted)

In [5]:
```
# TEST
# Make sure you have all the columns from both tables
set(["Name", "Menu_Item", "Yelp", "Google", "Overall", "Cost"]) == set(b
urritos.labels)
```

Out[5]:
```
True
```

In [6]:
```
# TEST
burritos.num_rows == 212
```

Out[6]:
```
True
```

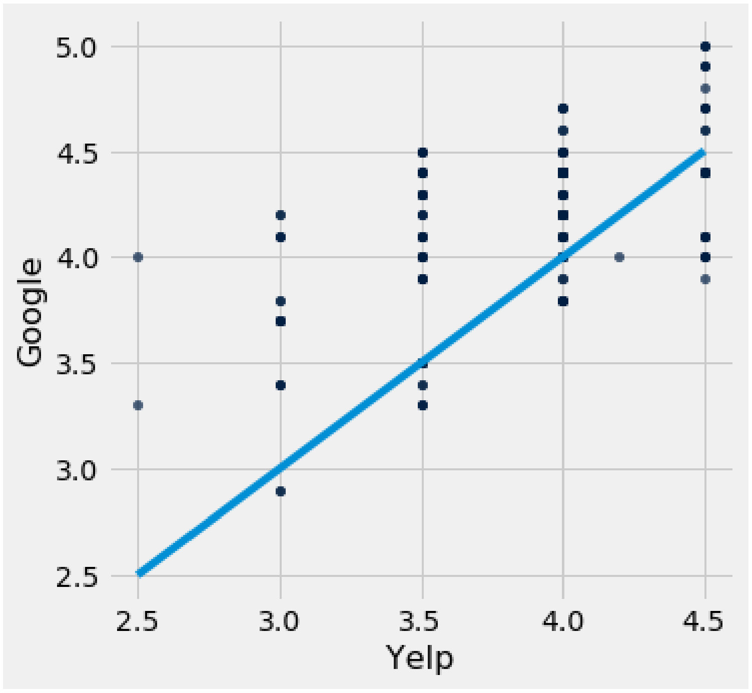
In [7]:
```
# HIDDEN TEST
len(np.unique(burritos.group('Name').column(1)))
```

Out[7]:
```
10
```

Question 2. Let's look at how the Yelp scores compare to the Google scores in the `burritos` table. First, assign `yelp_and_google` to a table only containing the columns `Yelp` and `Google`. Then, make a scatter plot with Yelp scores on the x-axis and the Google scores on the y-axis.

```
BEGIN QUESTION
name: q1_2
manual: True
```

In [8]:
```
yelp_and_google = burritos.select("Yelp", "Google") # SOLUTION
yelp_and_google.scatter("Yelp", "Google") # SOLUTION
# Don't change/edit/remove the following line.
# To help you make conclusions, we have plotted a straight line on the g
raph (y=x)
plt.plot(np.arange(2.5,5,.5), np.arange(2.5,5,.5));
```



Question 3. Looking at the scatter plot you just made in Question 1.2, do you notice any pattern(s) (i.e. is one of the two types of scores consistently higher than the other one)? If so, describe them **briefly** in the cell below.

```
BEGIN QUESTION
name: q1_3
manual: True
```

SOLUTION: The Google ratings are consistently higher than the Yelp ratings, and we can see a positive association between the two variables.

Here's a refresher on how `.group` works! You can read how `.group` works in the textbook (https://www.inferentialthinking.com/chapters/08/2/Classifying_by_One_Variable.html), or you can view the video below. The video resource was made by a past staff member - Divyesh Chotai!

```
In [9]: from IPython.display import YouTubeVideo
        YouTubeVideo("HLoYTCUP0fc")
```

```
Out[9]:
```

Question 4. From the `burritos` table, some of the restaurant locations have multiple reviews. Winifred thinks California burritos are the best type of burritos, and wants to see the average overall rating for California burritos at each location. Create a table that has two columns: the name of the restaurant and the average overall rating of California burritos at each location.

Tip: Revisit the burritos table to see how California burritos are represented.

Note: you can break up the solution into multiple lines, as long as you assign the final output table to `california_burritos`! For reference however, the staff solution only used one line.

```
BEGIN QUESTION
name: q1_4
```

In [10]:
```
california_burritos = burritos.where("Menu_Item", "California").drop("Me
nu_Item", "Yelp", "Google", "Cost").group("Name", np.average) # SOLUTION
california_burritos
```

Out[10]:

Name	Overall average
Burros and Fries	3.575
Caliente Mexican Food	3.25
California Burrito Company	3.2
Cancun Mexican & Seafood	4.1
Cotixan	3.6
Don Carlos Taco Shop	3.3
El Dorado Mexican Food	4.025
El Indio	4
El Pueblo Mexican Food	4.3
El Zarape	3.54815

... (36 rows omitted)

In [11]:
```
# TEST
# Number of columns should be 2
california_burritos.num_columns == 2
```

Out[11]:
```
True
```

In [12]:
```
# TEST
# Number of rows should be 46
california_burritos.num_rows == 46
```

Out[12]:
```
True
```

In [13]:
```
# HIDDEN TEST
california_burritos.take(40).column(0).item(0) == 'Taco Stand Encinitas'
```

Out[13]:
```
True
```

Question 5. Given this new table `california_burritos` , Winifred can figure out the name of the restaurant with the highest overall average rating! Assign `best_restaurant` to a line of code that evaluates to a string that corresponds to the name of the restaurant with the highest overall average rating.

```
BEGIN QUESTION
name: q1_5
```

In [14]:
```
best_restaurant = california_burritos.sort("Overall average", descending
=True).column("Name").item(0) # SOLUTION
best_restaurant
```

Out[14]:
```
'Mikes Taco Club'
```

In [15]:
```
# TEST
type(best_restaurant) == str
```

Out[15]:
```
True
```

In [16]:
```
# HIDDEN TEST
best_restaurant == "Mikes Taco Club"
```

Out[16]:
```
True
```

Question 6. Using the `burritos` table, assign `menu_average` to a table that has three columns that uniquely pairs the name of the restaurant, the menu item featured in the review, and the average Overall score for that menu item at that restaurant.

Hint: Use .group, and remember that you can group by multiple columns. Here's an example from the textbook (https://www.inferentialthinking.com/chapters/08/3/Cross-Classifying_by_More_than_One_Variable.html).

```
BEGIN QUESTION
name: q1_6
```

In [17]:
```
menu_average = burritos.group(make_array("Name", "Menu_Item"), np.averag
e).select("Name", "Menu_Item", "Overall average") # SOLUTION
menu_average
```

Out[17]:

Name	Menu_Item	Overall average
Albertacos	California	3.45
Albertacos	Carne asada	3.45
Burrito Factory	Steak everything	3.5
Burros and Fries	California	3.575
Burros and Fries	Carne asada	3.575
Burros and Fries	Shrimp california	3.575
Caliente Mexican Food	California	3.25
Caliente Mexican Food	carne asada	3.25
Caliente Mexican Food	fried fish	3.25
California Burrito Company	California	3.2

... (196 rows omitted)

```
In [18]: # TEST
         # Number of columns of the resulting table should be 3
         menu_average.num_columns == 3

Out[18]: True
```

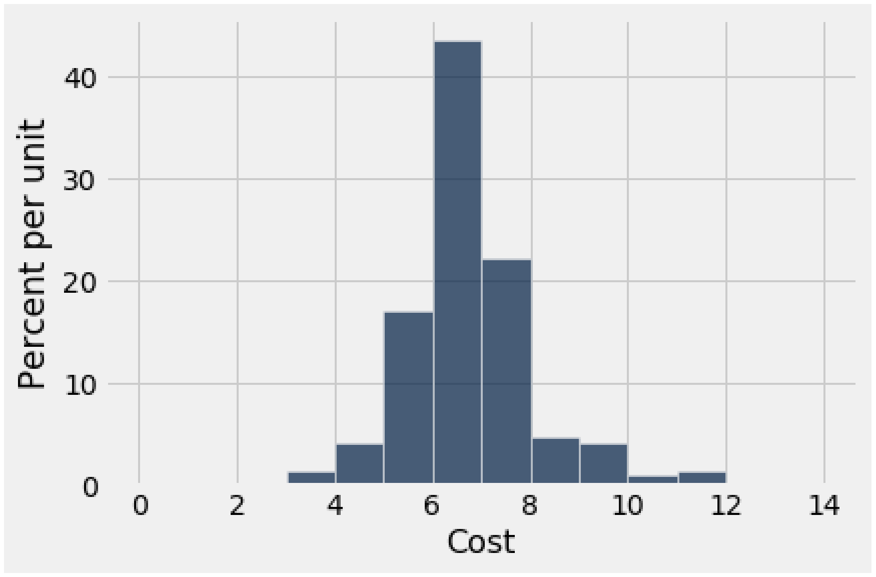
```
In [19]: # HIDDEN TEST
         sum(menu_average.group('Name').column(1)) == 206

Out[19]: True
```

Question 7. Tam thinks that burritos in San Diego are cheaper (and taste better) than the burritos in Berkeley. Plot a histogram that visualizes that distribution of the costs of the burritos from San Diego in the `burritos` table. Also use the provided `bins` variable when making your histogram, so that visually the histogram is more informative.

```
BEGIN QUESTION
name: q1_7
manual: True
```

```
In [20]: bins = np.arange(0, 15, 1)
         # Please also use the provided bins
         burritos.hist("Cost", bins = bins) # SOLUTION
```



2. Faculty salaries

This exercise is designed to give you practice using the Table methods `pivot` and `group`. Here (http://data8.org/sp20/python-reference.html) is a link to the Python reference page in case you need a quick refresher.

Run the cell below to view a demo on how you can use pivot on a table. (Thank you to past staff Divyesh Chotai)

In [21]:
```
from IPython.display import YouTubeVideo
YouTubeVideo("4WzXo8eKLAg")
```

Out[21]:

In the next cell, we load a dataset created by the Daily Cal (http://projects.dailycal.org/paychecker/) which contains Berkeley faculty, their departments, their positions, and their gross salaries in 2015.

In [22]:
```
raw_profs = Table.read_table("faculty.csv").where("year", are.equal_to(2
015)).drop("year", "title")
profs = raw_profs.relabeled("title_category", "position")
profs
```

Out[22]:

name	department	position	gross_salary
CYNTHIA ABAN	South & Southeast Asian Studies	lecturer	64450
PIETER ABBEEL	Computer Science	associate professor	184998
SALLY ABEL	Law	lecturer	3466
ELIZABETH ABEL	English	professor	138775
DOR ABRAHAMSON	Education	associate professor	100300
KATHRYN ABRAMS	Law	professor	319693
BARBARA ABRAMS	Public Health	professor	191162
SARAH ACCOMAZZO	Social Welfare	lecturer	14779
CHARISMA ACEY	City and Regional Planning	assistant professor	101567
DAVID ACKERLY	Biology	professor	182288

... (2049 rows omitted)

We want to use this table to generate arrays with the names of each professor in each department.

Question 1. Set `prof_names` to a table with two columns. The first column should be called `department` and have the name of every department once, and the second column should be called `faculty` with each row in that second column containing an *array* of the names of all faculty members in that department.

Hint: Think about how `group` works: it collects values into an array and then applies a function to that array. We have defined two functions below for you, and you will need to use one of them in your call to `group` .

```
BEGIN QUESTION
name: q2_1
```

In [23]:
```
# Pick one of the two functions defined below in your call to group.
def identity(array):
    '''Returns the array that is passed through'''
    return array

def first(array):
    '''Returns the first item'''
    return array.item(0)

# Make a call to group using one of the functions above when you define
 prof_names
prof_names = profs.drop("position", "gross_salary").group("department",
identity).relabeled("name identity", 'faculty') # SOLUTION
prof_names
```

Out[23]:

department	faculty
African American Studies	['AYA DE LEON' 'CHIYUMA ELLIOTT' 'NIKKI JONES' 'DAVID KY ...
Agricultural and Resource Economics and Policy	['MAXIMILIAN AUFFHAMMER' 'CHARLES GIBBONS' 'JEFFREY PERL ...
Anthroplogy	['SABRINA AGARWAL' 'STANLEY BRANDES' 'CHARLES BRIGGS' ' ...
Architecture	['MARK ANDERSON' 'JACOB ATHERTON' 'WILLIAM ATWOOD' 'R.GA ...
Art History	['DILIANA ANGELOVA' 'PATRICIA BERGER' 'JULIA BRYAN-WILSO ...
Art Practice	['ALLAN DESOUZA' 'AIDA GAMEZ' 'RANDY HUSSONG' 'JENNIFER ...
Astronomy	['GIBOR BASRI' 'STEVEN BECKWITH' 'LEO BLITZ' 'EUGENE CHI ...
Bioengineering	['ADAM ARKIN' 'IRINA CONBOY' 'STEVEN CONOLLY' 'JOHN DUEB ...
Biology	['DAVID ACKERLY' 'HILLEL ADESNIK' 'KELLY AGNEW' 'DORIS B ...
Buddhist Studies	['JANN RONIS']

... (61 rows omitted)

In [24]:
```
# TEST
prof_names.num_columns
```

Out[24]:
```
2
```

In [25]:
```
# TEST
prof_names.num_rows
```

Out[25]:
```
71
```

```
In [26]: # TEST
         # Make sure that you have the correct column labels!
         np.asarray(prof_names.labels).item(1) != "name identity"

Out[26]: True
```

```
In [27]: # TEST
         # Make sure that you have the correct column labels!
         np.asarray(prof_names.labels).item(1) == "faculty"

Out[27]: True
```

```
In [28]: # HIDDEN TEST
         len(prof_names.where('department', 'Computer Science').column('faculty')
         .item(0))

Out[28]: 46
```

```
In [29]: # HIDDEN TEST
         len(prof_names.where('department', 'Mathematics').column('faculty').item
         (0))

Out[29]: 48
```

Understanding the code you just wrote in 2.1 is important for moving forward with the class! If you made a lucky guess, take some time to look at the code, step by step.

Question 2. At the moment, the `name` column of the `profs` table is sorted by last name. Would the arrays you generated in the `faculty` column of the previous part be the same if we had sorted by first name instead before generating them? Two arrays are the **same** if they contain the same number of elements and the elements located at corresponding indexes in the two arrays are identical. An example of arrays that are NOT the same: `array([1,2]) != array([2,1])` . Explain your answer.

```
BEGIN QUESTION
name: q2_2
manual: true
```

SOLUTION: If the order of the names in a department changes after we sort by first name, then that will also change the array we get back. That is because `group` does a sequential search of the table (from top to bottom) and collects the values in the array in the order in which they appear.

Question 3. Set `department_ranges` to a table containing departments as the rows, and the position as the columns. The values in the rows should correspond to a salary range, where range is defined as the **difference between the highest salary and the lowest salary in the department for that position.**

Hint: First you'll need to define a new function `salary_range` which takes in an array of salaries and returns the range of salaries in that array.

```
BEGIN QUESTION
name: q2_3
manual: false
```

In [30]:
```
# Define salary_range first
def salary_range(salaries): #SOLUTION
    return max(salaries) - min(salaries) # SOLUTION

department_ranges = profs.pivot("position", "department", "gross_salary"
, salary_range) # SOLUTION
department_ranges
```

Out[30]:

department	assistant professor	associate professor	lecturer	professor
African American Studies	128828	48814	83309	0
Agricultural and Resource Economics and Policy	0	0	0	29650
Anthroplogy	11193	103271	11131	166527
Architecture	47675	103204	72977	167892
Art History	57288	27439	31861	100894
Art Practice	0	26632	93923	0
Astronomy	0	0	0	138346
Bioengineering	5513	2794	69008	134739
Biology	209667	113341	137087	288554
Buddhist Studies	0	0	0	0

... (61 rows omitted)

In [31]:
```
# TEST
# Double check that your salary_range function is correct
salary_range(make_array(5, 1, 20, 1000)) == 999
```

Out[31]:
```
True
```

In [32]:
```
# TEST
set(["department", "assistant professor", "associate professor", "lectur
er", "professor"]) == set(department_ranges.labels)
```

Out[32]:
```
True
```

```
In [33]: # TEST
         sum(department_ranges.column(1))

Out[33]: 2976273.0
```

```
In [34]: # HIDDEN TEST
         department_ranges.take(3)
```

Out[34]:

department	assistant professor	associate professor	lecturer	professor
Architecture	47675	103204	72977	167892

Question 4. Give an explanation as to why some of the row values are `0` in the `department_ranges` table from the previous question.

```
BEGIN QUESTION
name: q2_3
manual: True
```

SOLUTION: Either the salary range is actually 0 (if the max salary was the same as the min salary), or that there was missing data for the row/column pair.

3. Submission

Once you're finished, select "Save and Checkpoint" in the File menu and then execute the `submit` cell below. The result will contain a link that you can use to check that your assignment has been submitted successfully. If you submit more than once before the deadline, we will only grade your final submission. If you mistakenly submit the wrong one, you can head to okpy.org (https://okpy.org/) and flag the correct version. To do so, go to the website, click on this assignment, and find the version you would like to have graded. There should be an option to flag that submission for grading!

```
In [35]: _ = ok.submit()

         ------------------------------------------------------------------------
         ----
         NameError                                 Traceback (most recent call l
         ast)
         <ipython-input-35-cc46ca874451> in <module>
         ----> 1 _ = ok.submit()

         NameError: name 'ok' is not defined
```

In [36]:
```
# For your convenience, you can run this cell to run all the tests at on
ce!
import os
print("Running all tests...")
_ = [ok.grade(q[:-3]) for q in os.listdir("tests") if q.startswith('q')
and len(q) <= 10]
print("Finished running all tests.")
```

```
Running all tests...
Finished running all tests.
```