Assignment 3: arXiv

Due Nov 30 by 4p.m. **Points** None

Assignment 3: Working with arXiv.org Metadata

In Assignment 3, you'll work with data from a popular website for disseminating scholarly work. To complete the assignment, you will need the material from Weeks 1 to 9 of the course, although you can get started on it prior to completing Week 9.

This handout explains the problem being solved, and the tasks to complete. Please read it carefully and in its entirety.

Logistics

- **Due Date**: Thursday, November 30 before 4:00PM (Toronto time)
- Submission: You will submit your assignment solution on MarkUs.
- Late Policy: There are penalties for submitting the assignment after the due date. These penalties depend on how many hours late your submission is. Please see the syllabus on Quercus for more information.
- No Remark Requests: No remark requests will be accepted. A syntax error could result in a grade of 0 on the assignment. Before the deadline, **you are responsible** for running your code and the checker program to identify and resolve any errors that will prevent our tests from running. The best way to check for this is to run the tests on MarkUs via the Automated Testing tab for this assignment.
- The work you submit must be your own. Please review **The Code of Behaviour on Academic Matters (http://www.governingcouncil.utoronto.ca/policies/behaveac.htm)** and **information for students (https://www.artsci.utoronto.ca/current/academic-advising-and-support/student-academic-integrity)** from the Office of Student Academic Integrity.
- See Quercus for information on requesting special consideration.

Goals of this Assignment

In this assignment, you will practice working with files, building and using dictionaries, designing functions using the Function Design Recipe, and writing tests in pytest. You will also continue to practice your skills in testing and debugging using the Wing101 debugger.

Introduction: arxiv.org

arxiv.org (https://arxiv.org/) is a free distribution service and an open-access archive for over two million scholarly articles in the fields of physics, mathematics, computer science, quantitative biology, quantitative finance, statistics, electrical engineering and systems science, and economics. **arXiv is pronounced as "archive" (https://en.wikipedia.org/wiki/ArXiv)** .

arxiv.org (https://arxiv.org/) maintainers believe in open, free, and accessible information. In addition to free and easy access to the articles themselves, arxiv.org also provides ways to **access its metadata (https://arxiv.org/help/bulk_data)** . This metadata includes information such as the article's unique identification number, author(s), title, abstract, the date the article was added to the arxiv and when it was last modified, license under which the article was published, etc. This metadata is used by a variety of research tools that investigate scientific research trends, provide intelligent scientific search techniques, and in many other areas.

To make this assignment more manageable for you, we have extracted a sample of arxiv's metadata, simplified it, and created a text file you will use as input to your program.

The Metadata File

The metadata file contains a series of one or more article descriptions, one after the other. Each article description has the following elements, in order:

1. A line containing a unique identifier of the article. An identifier will appear only once in the file and not contain any whitespace.
2. A line containing the article's title. If no title information is provided, this line will be blank.

3. A line containing the article's created date in the format of `YYYY-MM-DD`. If no creation date is provided, this line will be blank.
4. A line containing the article's last modified date in the format of `YYYY-MM-DD`. If no modified date is provided, this line will be blank.
5. Zero or more lines with the article's author(s). Each line contains an author's last name followed by a comma `,` followed by the author's first name(s). There is always exactly one comma `,` on the author line. An author's name may have white space and/or punctuation other than commas. Immediately after the zero or more author lines, a single blank line will indicate that there are no more authors. (If we do not have any author information for an article, then the blank line will come immediately after the modification date line.)
6. Zero or more lines of text containing the abstract of the article.
7. A line containing the word `END`. This delimitates the end of the article description and either the beginning of the next article description or the end of the file. You may assume that a line with only `END` in it does not occur in any other context in the metadata file.

You can assume that any file we test your code with has this structure. You do not need to handle any invalid file formats.

Example Metadata File

Here is an example metadata file (also provided in the starter code later **(a3.zip)**):

```
5090
Increasing Students' Engagement to Reminder Emails

2022-08-02
Yanez,Fernando
Zavaleta-Bernuy,Angela

Our metric of interest is open email rates.
END
03221
Stargazer: An Interactive Camera Robot for How-To Videos
2023-03-01
2023-03-06
Grossman,Tovi

We present Stargazer, a novel approach for assisting with tutorial content creation.
END
0001
```

```
Cats and Dogs Can Co-Exist
2023-08-20
2023-10-02
Smith,Jacqueline E.
Sharmin,Sadia

We show a formal proof that cats and dogs
can peacefully co-exist!
END
108
CSC108 is the Best Course Ever
2023-09-01

Smith,Jacqueline E.
Zavaleta-Bernuy,Angela
Campbell,Jen

We present clear evidence that Introduction to
Computer Programming is the best course
END
42

2023-05-04
2023-05-05

This is a strange article with no title
and no authors.

It also has a blank line in its abstract!
END
```

This metadata file contains information on five articles with unique identifiers `'5090'`, `'03221'`, `'0001'`, `'827'`, and `'42'`. Notice that the following information is **not** provided in the file: modified date in article `'108'`, created date in article `'5090'`, and title and authors in article `'42'`. All these are valid cases, and your code should deal with them.

Storing the Arxiv Metadata

We will use a dictionary to maintain the arxiv metadata. Let us look in detail at the format of this dictionary. The types below are defined in `constants.py` and we have imported them into `arxiv_functions.py` for use in your type contracts.

Type `NameType`

We will store the names of authors as tuples of two strings: the author's last name(s) and the author's first name(s). For example, the author `Sadia Sharmin` would be listed in

the metadata file as `'Sharmin,Sadia'` and will be stored as `('Sharmin', 'Sadia')`. Note, that there may be punctuation characters (except for commas) and/or white space included in an author's last name and/or first name, and we need to keep all this information. For example, `Smith,Jacqueline E.`, `Van Dyke,Mary-Ellen` and `Sklodowska Curie,Marie Salomea` are all valid input lines, and should be stored as `('Smith', 'Jacqueline E.')`, `('Van Dyke', 'Mary-Ellen')` and `('Sklodowska Curie', 'Marie Salomea')`, respectively. A line like `Smith,Jacqueline,E.` is **not** valid, since it contains two commas, and we cannot tell which is supposed to be the first and which is the last name. You can assume all inputs are valid and both first and last names are non-empty strings.

Type `ArticleType` and type `ArticleValueType`

The file `constants.py` in the starter code defines the following constants that you should use instead of the literal strings. Below are the current values of the constants.

```
ID = 'identifier'
TITLE = 'title'
CREATED = 'created'
MODIFIED = 'modified'
AUTHORS = 'authors'
ABSTRACT = 'abstract'
```

We will store information about a single article in a dictionary that maps `ID`, `TITLE`, `CREATED`, `MODIFIED`, `AUTHORS`, and `ABSTRACT` to their corresponding values. The value for each piece of information is of type `ArticleValueType`, which is of type `str` for all values except for the value associated with key `AUTHORS`, which is a `list` of `NameType`. If an element is not provided in the metadata file, then the value associated with that key will be empty (i.e. the empty string, or in the case of no authors, an empty list).

For example, the article with the identifier `'108'` in our example input file above will be stored in the following dictionary:

```
{ID: '108',
 TITLE: 'CSC108 is the Best Course Ever',
 CREATED: '2023-09-01',
 MODIFIED: '',
 AUTHORS: [('Smith', 'Jacqueline E.'), ('Zavaleta-Bernuy', 'Angela'), ('Campbell', 'Je
n')],
 ABSTRACT: 'We present clear evidence that Introduction to\nComputer Programming is the be
st course.'}
```

Notice that since the fourth line in the specification is blank, the value corresponding to key `MODIFIED` is the empty string. Also notice that the final newline character on each line is not included in any of the stored values, except for the newline characters *inside* the abstract — we keep those! Take a careful look at the starter file `example_data.txt` (same as the example above) and the corresponding dictionary `EXAMPLE_ARXIV` defined in the file `arxiv_functions.py` for more examples.

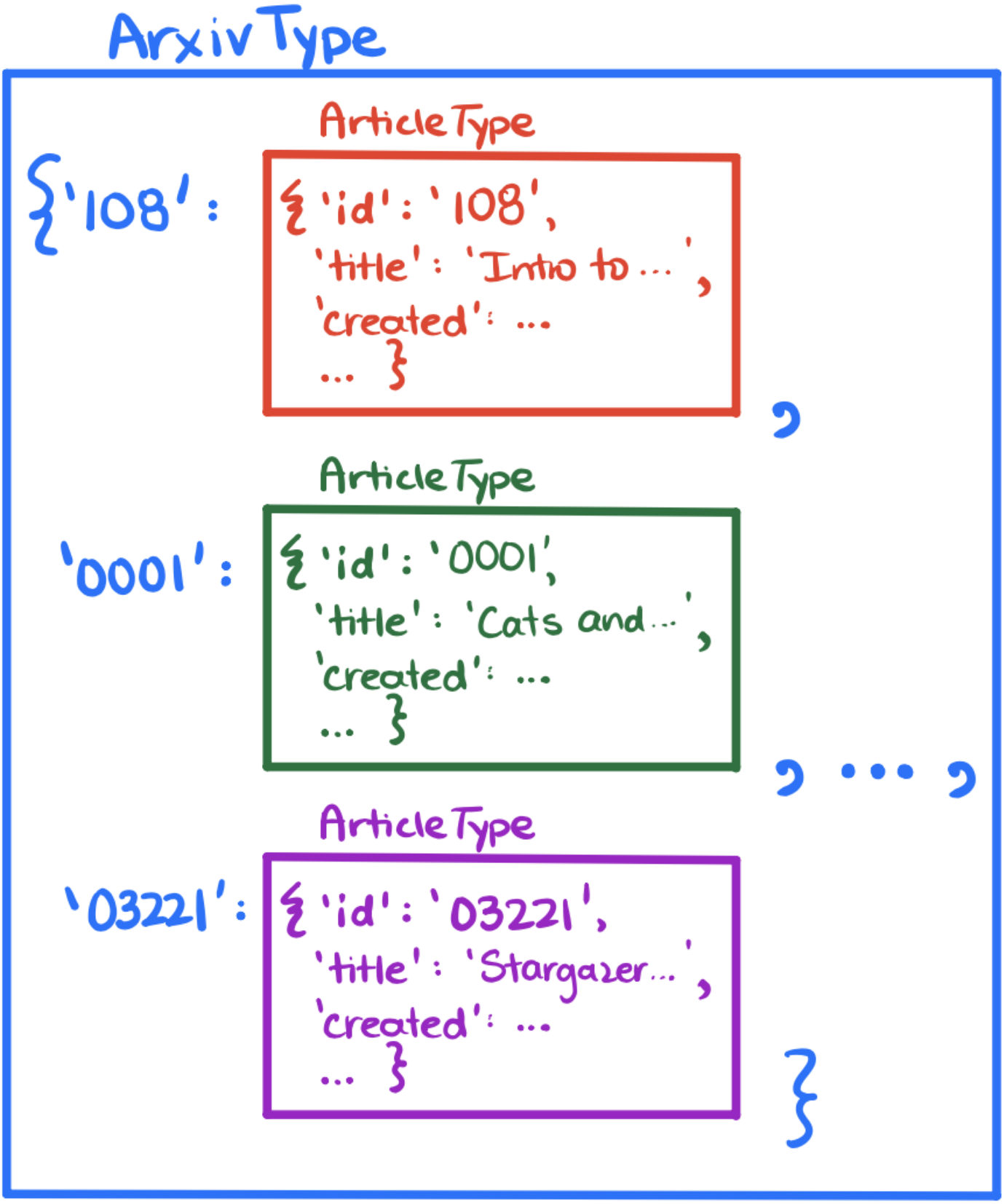
Type `ArxivType`

Finally, we will store the entire arxiv metadata in a dictionary that maps article identifiers to articles, i.e. to values of type `ArticleType`. The key/value pair in this dictionary that corresponds to the above article is:

```
'108': {
    ID: '108',
    TITLE: 'CSC108 is the Best Course Ever',
    CREATED: '2023-09-01',
    MODIFIED: '',
    AUTHORS: [('Smith', 'Jacqueline E.'), ('Zavaleta-Bernuy', 'Angela'), ('Campbell', 'Je
n')],
    ABSTRACT: 'We present clear evidence that Introduction to\nComputer Programming is the
best course.'
}
```

A Diagram

The diagram below shows a picture of the dictionary that represents some of the articles in the `example_data.txt`. The keys for each `ArticleType` match the values in `constants.py`.



Files to Download

Download the Assignment 3 Files and unzip them (https://q.utoronto.ca/courses/314106/files/28683462?wrap=1) (https://q.utoronto.ca/courses/314106/files/28683462/download?download_frd=1) . Place all the files in the same folder. The following paragraphs explain the files you have been given.

- Python Code
  - The starter code for this assignment is in the `arxiv_functions.py`. You need to complete the file `arxiv_functions.py`. We have only provided the docstring for some of the required functions. You must add the other functions described in this handout.
  - The starter code for the required pytests are in the files `test_created_in_year.py` and `test_average_author_count.py`. You need to complete these files.
  - The file `constants.py` contains some code that is imported into the `arxiv_functions.py` file. You should not change this file, but you may find it helpful to read it.
  - The a3 checker's main file is `a3_checker.py`. It is complete and must not be changed. As in the previous assignments, there are some other files included which are for use by the checker. Keep them in the same folder, but there is nothing you need to do with them.
- Sample arxiv metadata
  - We have provided two text files containing sample data. The file `example_data.txt` corresponds exactly to the example we used throughout this handout. The file `data.txt` is much larger, albeit it is still a small part of the real data available on **arxiv.org (https://arxiv.org/)** .
- A reminder about the checker: We have provided a checker program (`a3_checker.py`) that tests two things:
  - whether your functions have the correct parameter and return types, and
  - whether your code follows the Python Style Guidelines.

The checker program does not test the correctness of your functions, so you must do that yourself.

Required Functions

In the starter code file `arxiv_functions.py`, follow the Function Design Recipe to complete the following functions. We have provided a few docstrings in the starter code, but you will need to write most of them yourself.

In addition to the functions below, you must add some helper functions (i.e. functions that you design yourself) to aid with the implementation of these required functions. These helper functions also require complete docstrings. We strongly recommend you use the suggested helper functions in the table below; we give you these hints to make your programming task easier.

Some indications that you should consider writing a helper function are:

- Reusing similar code to solve similar tasks across multiple functions
- Getting a warning from the checker that your function is too long
- Getting a warning from the checker that your function has too many nested blocks or too many branches
- Realizing that your function can be broken down into smaller sub-problems

For each of the required functions below, other than `read_arxiv_file`, write at least two examples in the docstrings that use the constant `EXAMPLE_ARXIV`. However, if your helper function takes an open file as an argument, you do NOT need to write any examples in that function's docstring.

Your functions should not mutate their arguments, unless the description says that is what they do.

A note on sorting: Throughout the assignment, we ask for lists to be sorted in *lexicographic order*. This is the order that Python sorts in (such as when you call `list.sort`). You do not have to write your own sorting code (unless you want to!)

We have broken the components of the assignment down into 5 Tasks, grouping related functions together. Some tasks are easier than others, and you can do the tasks in any order. As in the previous assignments, we'll be marking each function mostly separately (however there will be some overlap when functions call other functions).

Task 1: Working with `ArxivType` and using a helper function

Functions to implement in `arxiv_functions.py for Task 1`

Function name: (Parameter types) -> Return type	Full Description (paraphrase to get a proper docstring description)
`created_in_year: (ArxivType, str, int) -> bool`	The first parameter represents arxiv metadata, the second parameter is an article ID, and the third parameter is a year. This function should return True if and only if an article with the provided id occurs in the metadata and was published in the given year. Hint: Think about what the function should return if this ID is not found in the metadata.
`contains_keyword: (ArxivType, str) -> list[str]`	The first parameter represents arxiv metadata and the second parameter is a keyword to search for in the metadata. This function should return a list of the IDs of articles that contain the given keyword in their title, author names, and/or abstract. The list should be sorted in lexicographic order. This function should be case-insensitive and should ignore punctuation. For example, if the keyword is 'cat', then the keyword will match any titles with the words: "Cat", "c&at", "CAT", "c-at". Hint: make use of the provided helper function `clean_word`. The keyword should not be matched as a substring of a larger word. For example, if keyword is `'calc'`, then the function should not match with the title `'Calculus is Great'`. You may assume the keyword to search for is a non-empty lowercase string containing only alphabetic characters.
`average_author_count: (ArxivType) -> float`	The parameter represents arxiv metadata. This function should return the average number of authors per article in the arxiv

	metadata. If there are no articles, the function should return `0.0`. For example, if the metadata has two articles (one with four authors and one with one author), then the function should return an average author count of (4 + 1) / 2 = 2.5.

Task 2: Reading in the arxiv metadata file

Functions to implement in `arxiv_functions.py for Task 2`

Function name: (Parameter types) -> Return type	Full Description (paraphrase to get a proper docstring description)
`read_arxiv_file: (TextIO) -> ArxivType`	The parameter represents an arxiv metadata file that is **already open for reading**. This function should read the file and return the data in the `ArxivType` dictionary format. Take a careful look at the starter file `example_data.txt` (same as the example above) and the corresponding dictionary `EXAMPLE_ARXIV` defined in the file `arxiv_functions.py` for an example. Note: in the docstring, do not provide example calls for functions that read files. Hint: Notice that this is a structured file reading problem. It is also a good idea to design and write a couple of helper functions here.

Task 3: Working with Authors and Coauthors

Functions to implement in `arxiv_functions.py for Task 3`

Function name: (Parameter types) -> Return type	Full Description (paraphrase to get a proper docstring description)

`make_author_to_articles: (ArxivType) -> dict[NameType, list[str]]`	The parameter represents arxiv metadata. This function should return a dictionary that maps each author name to a list of ID's of articles written by that author. The list should be sorted in lexicographic order. For example, if the input is a dictionary that represents the information from our example metadata file, then `make_author_to_articles` should return the dictionary `{ ('Campbell', 'Jen'): ['108'], ('Grossman', 'Tovi'): ['03221'], ('Sharmin', 'Sadia'): ['0001'], ('Smith', 'Jacqueline E.'): ['0001', '108'], ('Yanez', 'Fernando'): ['5090'], ('Zavaleta-Bernuy', 'Angela'): ['108', '5090'] }` Note that the order of the key/value pairs in the dictionary could be different, and that's OK. However, the value lists must all be sorted to match the above. Hint: It is a good idea to build the dictionary first, and then sort the article lists (the values in the dictionary).
`get_coauthors: (ArxivType, NameType) -> list[NameType]`	The first parameter represents arxiv metadata and the second parameter represents an author's name. This function should return a list of coauthors of the author specified by the second argument. (Two people are coauthors if they are authors of the same article.) The list should be sorted in lexicographic order. Authors should appear in the list only once, even if they were a coauthor on more than one paper. For example, if the first argument is a dictionary that represents the information from our example metadata

	file and the second argument is `('Smith', 'Jacqueline E.')`, then this function should return the list `[('Campbell', 'Jen'), ('Sharmin', 'Sadia'), ('Zavaleta-Bernuy', 'Angela')].` Hint: Make sure you don't claim that a person is their own coauthor. Make sure your code does not crash if the author does not appear in the input dictionary at all! Consider using function(s) you already defined to simplify your solution.
`get_most_published_authors: (ArxivType) -> list[NameType]`	The parameter represents arxiv metadata. This function should return a list of authors with the most published articles (possibly more than one author can publish the most articles). The list should be sorted in lexicographic order. For example, if input is a dictionary that represents the information from our example metadata file, then this function should return the list `[('Smith', 'Jacqueline E.'), ('Zavaleta-Bernuy', 'Angela')]` Note: Because the example arxiv dictionary provided will always have one list of most published authors, you will need to create a second arxiv metadata dictionary for your second example for this function. Hint: Consider using function(s) you already defined to simplify your solution. Specifically, it is a good idea to implement the function `make_author_to_articles` before this one.

`suggest_collaborators: (ArxivType, NameType) -> list[NameType]`	The first parameter represents arxiv metadata and the second parameter represents the author's name. This function should return a list of authors with whom the author specified by the second argument is encouraged to collaborate. The list should be sorted in lexicographic order. The list of suggested collaborators should include all authors who are coauthors of this author's coauthors. In other words, if author `A` wrote an article with author `B` and author `B` wrote an article with author `C`, then we will include `C` as a suggested collaborator for `A`. For example, if the first argument is a dictionary that represents the information from our example metadata file and the second argument is `('Yanez', 'Fernando')`, then this function should return the list `[('Campbell', 'Jen'), ('Smith', 'Jacqueline E.')].` If the second argument is `('Grossman', 'Tovi')`, then this function should return an empty list. Hints: Consider using function(s) you already defined to simplify your solution. Make sure you do not include people who are already coauthors of the given author in the return list (they already know each other!). Make sure you don't include the author themselves as a suggested collaborator. Finally, make sure the resulting list does not contain any names more than once.

Task 4: Prolific Authors

Functions to implement in `arxiv_functions.py for Task 4`

Function name: (Parameter types) -> Return type	Full Description (paraphrase to get a proper docstring description)
`has_prolific_authors: (dict[NameType, list[str]], ArticleType, int) -> bool`	The first parameter is a dictionary mapping author names lists of IDs of articles published by that author, the second parameter represents the information of a single article, and the third argument represents the minimum number of publications required for an author to be considered prolific. The function should return True if and only if the article (second argument) has at least one author who is considered prolific. An author is prolific if they've published at least a minimum number of publications (third argument). For example, if the first argument is the dictionary `{ ('Campbell', 'Jen'): ['108'], ('Grossman', 'Tovi'): ['03221'], ('Sharmin', 'Sadia'): ['0001'], ('Smith', 'Jacqueline E.'): ['0001', '108'], ('Yanez', 'Fernando'): ['5090'], ('Zavaleta-Bernuy', 'Angela'): ['108', '5090'] }` the second argument is the article with ID `'5090'` from our example, and the third argument is `2`, then the function should return `True`, because at least one of the authors of the article with ID `'5090'` is "prolific", i.e., has published at least 2 papers. If the second argument is the article with ID `'03221'` (and the other arguments are the same), then the function should return `False`, since none of the authors of this article have published at least two papers. You can assume that every author of the article specified by the second argument also appears as a key in the first argument.

`keep_prolific_authors: (ArxivType, int) -> None`

The first parameter represents arxiv metadata and the second parameter represents the minimum number of publications required for an author to be considered prolific. The function should modify the passed in metadata to contain only articles published by prolific authors, i.e., articles that have at least one author who has published at least the minimum required number of articles.

For example, if the first argument is a dictionary that represents the information from our example metadata file and the second argument is `2`, then the function should modify its first argument by removing the articles with IDs `'03221'` and `'42'`, and keeping the articles with IDs `'108'`, `'5090'`, and `'0001'`.

Some hints:

- Notice that this function returns `None` and *modifies its argument*.
- Recall that in Python you never want to remove items from a dictionary while iterating over that same dictionary. One way to avoid this issue in your solution is to first decide on which articles should be removed from the dictionary, and then remove them in a separate loop.
- Consider using the functions `make_author_to_articles` and `has_prolific_authors` as helpers to simplify your solution.
- When writing tests for this function, remember that the function modifies its input. To make sure that the tests do not interfere with each other, we often create copies of sample input and pass these copies to the function we are testing.
- Take a careful look at the docstring for this function which we provided in the starter code and pay attention to the use of `copy.deepcopy` in the example calls.

Task 5: Required Testing (`pytest`)

Write and submit a set of pytest tests for the `created_in_year` and `average_author_count` functions. We have provided starter code in the `test_created_in_year.py` and `test_average_author_count.py` files. We have included one test that you can use as a template to write your other test methods. For each test method, include a brief docstring description specifying what is being tested. Do not write examples in the docstring.

Your set of tests should all pass on correct code and use appropriate methods for testing functions returning floats. Your tests should be thorough enough that at least one of them will fail on a buggy version of the function. There is no required number of tests; we will mark your tests by running them on the correct code as well as several buggy versions.

Marking Scheme

These are the aspects of your work that will be marked for Assignment 3:

- **Correctness (70%):** Your functions should perform as specified. Correctness, as measured by our tests, will count for the largest single portion of your marks. Once your assignment is submitted, we will run additional tests, not provided in the checker. Passing the checker **does not** mean that your code will earn full marks for correctness.
- **Testing (10%):** Your `pytest` test suite will be checked by running in on incorrect/broken implementations. Your tests should all pass on a correct version of the function, and at least one should fail on each of our broken implementations. Your tests will not be marked for style. Your tests should be appropriate for the return type of the function you are testing.
- **Coding style (20%):** Make sure that you follow Python style guidelines that we have introduced and the Python coding conventions that we have been using throughout the semester. Although we don't provide an exhaustive list of style rules, the checker tests for style are complete. So, if your code passes the checker, then it will earn full marks for coding style with one exception: docstrings and the creation

of helper functions may be evaluated separately. For each occurrence of a PyTA error as reported by the checker, a mark deduction will be applied. Make sure you review the **CSC108 Python Style Guidelines (https://q.utoronto.ca/courses/314106/pages/python-style-guidelines)** for the rules on how to write a docstring description. You may also refer to the **PythonTA Checks (https://www.cs.toronto.edu/~david/pyta/checkers/index.html)** webpage for a more comprehensive list of styling related checks by looking up the corresponding error codes mentioned in the a2 checker.

No Remark Requests

As mentioned earlier: No remark requests will be accepted. A syntax error could result in a grade of 0 on the assignment. Before the deadline, **you are responsible** for running your code and the checker program to identify and resolve any errors that will prevent our tests from running. You should do a final check on the code you submit by running the tests on MarkUs via the Automated Testing tab for this assignment.

What to Hand In

Submit `arxiv_functions.py`, `test_created_in_year.py`, and `test_average_author_count.py` on MarkUs.

The very last thing you do should be to run the checker program one last time.

Otherwise, you could make a small error in your final changes before submitting that causes your code to receive zero for correctness. We do not accept remark requests for 108 assignments, including for cases like this. Before the deadline, you are responsible for running your code and the checker program to identify and resolve any errors that will prevent our tests from running.