MODULE 2 PROJECT: ARRAY-BASED LISTS

Learning objectives:

CLO 1. Identify fundamental data structures in computer science and their use in real-life applications.

CLO 3. Develop problem solving skills by implementing data structures.

CLO 4. Compare advantages and disadvantages of different data structure implementations.

Data Structure Implementations

1. Implement the `ArrayStack`, `ArrayQueue` and `ArrayList` data structures covered Module 2 (Array-Based Lists). All the data structures should be fully functional and must follow the logic presented in the lecture.

   You have to modify the files,

   - **ArrayStack.py**
   - **ArrayQueue.py**
   - **ArrayList.py**

   Test your data structures by doing the following using the following tests.

   - Remove one element from an empty ArrayStack/ArrayQueue/ArrayList. This should result in an `IndexError`.
   - Stack: Add 5 elements and remove them checking that they are in opposite order of insertion, e.g., Inserting the sequence 5,4,3,2,1 should result in the sequence 1,2,3,4,5 when removing.
   - Queue: Add 5 elements and remove them checking that they are in the same order of insertion, e.g., Inserting the sequence 1,2,3,4,5 should result in the sequence 1,2,3,4,5 when removing.
   - List: Add 5 elements in different positions (including the first and last) and check that they are in order, e.g., `add(0,4), add(0,1), add(1,3), add(1,2)`, and `add(4,5)` should result in the array `[1, 2, 3, 4, 5]`. Remove 2 elements, e.g., index 2 and 3 and the final array should be `[1, 2, 4]`.

2. Implement `RandomQueue` so that the `remove()` function removes an element at random from amongst the elements currently in the queue. The `add(x)` and `remove()` operations in a RandomQueue should run in amortized constant time per operation.

   You have to modify the file **RandomQueue.py.**

   Hint: Use the random method `randint()` from the module `random` to return random numbers.

   Test your `RandomQueue` using the following tests.

   - Remove one element from an empty `RandomQueue`. This should result in an `IndexError`.
   - Add 5 elements then remove them all. Check that the `remove()` function returns random value.

Edits to the Calculator Application

A *mathematical expression* is a sequence of numbers, letters and grouping characters that are properly matched. For example, `a+(b*c+ d)/(a-c)` is a matched expression, but `a+(b*c+d/(a-c)` is not.

Implement the function `matched_expression()` in the module **Calculator.py** so that it returns `True` if a given string expression contains a matched mathematical expression, `False`, otherwise. Your function's algorithm should run in $O(n)$ time.

Test your function by running `main.py` and then selecting option 1 of the calculator menu. Try entering different matched and unmatched expressions such as `(3+x)(2(x-1)+7)`, `)+3(x+2)`, `((x-1)`, etc. The empty expression is considered to be a matched expression.

Hint: Use an `ArrayStack` object in the implementation of `matched_expression()`. Consider the invariant that for every closed parenthesis, there must be one open parenthesis.

Edits to the BookStore Application

1. In **BooksStore.py**, verify that:

   (a) the attribute `self.shoppingCart` is initialized as an empty `ArrayQueue` object in the constructor.

   (b) the `load_catalogue()` function loads the attribute `self.bookCatalog` as an `ArrayList` object.

2. In **BooksStore.py**, modify the function `searchBookByInfix(infix)` so that it takes an additional parameter `cnt`. This parameter should be given an integer value when the function is called, i.e., the function should become

   ```
   def searchBookByInfix(infix : str, cnt : int):
   ```

   Then, implement this function so prints the first `cnt` books/DVD's (or less if there are not at least `cnt`) in the loaded catalog that contain the substring given by `infix`. The loaded catalog should be the array list object `self.bookCatalog`.

   Hint: Use a for loop and the `in` operator to test whether the infix is found in a book title.

You can test your bookstore system by running main.py and selecting option 2 (bookstore system). Then, in the bookstore application submenu, test the following options:

Option 1: Load the `booktest.txt` catalog. This is a subset of 12 books from the larger database.

Option 3: Add a book by index to the shopping cart. You must enter the index i of the book in the catalog. The index corresponds to the position that the `Book` was stored in the array list. It is NOT the same thing as the book key. Since there are only 12 books, you should enter an index in the range 0 to 11, inclusive. This should be fully functional if your implementations of `ArrayList` and `ArrayQueue` are complete and correct. Observe that this operation emulates adding a book to a shopping cart in any online store. Repeat this process to add 5 more books.

Option r: Select this option to transfer your current shopping cart to a random shopping cart. You will be able to verify if this worked in the next step.

Option 4: Remove a book from the shopping cart. Repeat the process 5 more times. If `RandomQueue` has been implemented correctly, the books will be displayed in random order (i.e., not in the queue order that you added them).

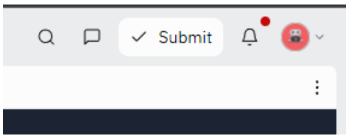
Repeat option 3 and option 4 but do not transfer the books to a random shopping cart. This time the books should display in queue order, i.e. in the order you added them to the cart.

Option 5: Search a book by title: Give an infix of an existing title and the max number of matches that you want displayed. For example, if you perform a search with the infix "Ma" and count 10, the application should display 2 titles.

SUBMISSION PROCESS

1. Submit your project for review on Repl.it.

You can find the "Submit" button on the top right-hand corner of your Repl.it workspace.



2. Modify and download the following files:

Since you will not be uploading all files from the projects template to CodePost, you must modify some lines of code prior to submitting. Modify the following modules:

- `Calculator.py`
  1. Comment out these unnecessary imports:
     - `import BinaryTree`,
     - `import ChainedHashTable`
     - `import DLList`
     - `import operator`.

     Only the `numpy` and `ArrayStack` imports should be left un-commented.
  2. Assign the attribute `self.dict` to be `None`

  Your `Calculator` module should look like this after you have made the edits listed above:

```
# ------------------- COMMENT OUT THESE IMPORTS ------------------#
# import BinaryTree
# import ChainedHashTable
# import DLList
# import operator
# ----------------------------------------------------------------#
import numpy as np
import ArrayStack

class Calculator:

    def __init__(self) :
        self.dict = None #ChainedHashTable.ChainedHashTable(DLList.DLList)
```

- BookStore.py
  1. Comment out these unnecessary imports:
     - import DLList
     - import SLLQueue
     - import ChainedHashTable
     - import BinarySearchTree
     - import BinaryHeap
     - import AdjacencyList

  Your BookStore module should look like this after you have made the edits listed above:

```
import Book
import ArrayList
import ArrayQueue
import RandomQueue
#------------------------ COMMENT OUT THESE IMPORTS ------------------------#
# import DLList
# import SLLQueue
# import ChainedHashTable
# import BinarySearchTree
# import BinaryHeap
# import AdjacencyList
#---------------------------------------------------------------------------#
import time



class BookStore:
    '''
    BookStore: It simulates a book system such as Amazon. It allows  searching,
    removing and adding in a shopping cart.
    '''
    def __init__(self) :
        self.bookCatalog = None
        self.shoppingCart = ArrayQueue.ArrayQueue()
```

3. Submit to CodePost

- `ArrayStack.py`
- `ArrayQueue.py`
- `ArrayList.py`
- `RandomQueue.py`
- `Calculator.py` - with modifications above
- `BookStore.py` - with modifications above
- `main.py`

RUBRIC

	Full Credit 2 pts.	Partial Credit pts. vary; See CodePost.	No Credit 0 pts.
ArrayStack implementation	Implementation is correct and passes all CodePost tests.	Implementation is partially correct. Fails one or more CodePost tests	Implementation is incorrect/incomplete and fails all CodePost tests.
ArrayQueue implementation	Implementation is correct and passes all CodePost tests.	Implementation is partially correct; fails one or more CodePost tests.	Implementation is incorrect/incomplete and fails all CodePost tests.
ArrayList implementation	Implementation is correct and passes all CodePost tests.	Implementation is partially correct; fails one or more CodePost tests.	Implementation is incorrect/incomplete and fails all CodePost tests.
RandomQueue implementation	Implementation is correct and passes all CodePost tests.	Implementation is partially correct; fails one or more CodePost tests.	Implementation is incorrect/incomplete and fails all CodePost tests.
Validating mathematical expression	Implementation is correct and passes all CodePost tests.	Implementation is partially correct; fails one or more CodePost tests.	Implementation is incorrect/incomplete and fails all CodePost tests.
Searching books by infix	Implementation is correct and passes all CodePost tests.	Implementation is partially correct; fails one or more CodePost tests.	Implementation is incorrect/incomplete and fails all CodePost tests.