MODULE 4 PROJECT: HASH TABLES

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.

CLO 5. Design and analyze composite data structures.

Data Structure Implementation

Files to Modify: ChaineHashTable.py.

Directions: Implement the `ChainedHashTable` data structure with operations,

- `add(k, v)` - adds an item with key `k` and `v` if the key does not already exist in the table (i.e. no items with duplicate keys are allowed). Returns `True` if the item was added successfully, `False` otherwise.
- `find(k)` - returns the value of the item with key `k` if it exists in the table, `None` otherwise
- `remove(k)` - removes the item with key `k` and returns the value, if the key `k` exists in the table. Otherwise, returns `None`
- `size()` - returns the number of items in the table

Recall that each bin in the hash table stores a list of elements that share in common the same hash value. You can use the already-implemented `_hash(key)` method to determine which bin each element must be added to.

(Optional) Test your program:

- Remove one element from an empty `ChainedHashTable`. Should return `None`
- Search in an empty `ChainedHashTable`: `find(2)` should return `None`
- Add 3 elements: `add(1,"first")`, `add(2, "second")`, `add(3, "fourth")`
- Attempt to add an element with existing key 3: `add(3, "third")`. Print the outcome, it should be `False`
- Check that `size()` returns 3
- Remove one element: `remove(3)` and check that `size()` returns 2.
- Find one element: `find(3)` should return `None`
- Add 3 elements: `add(3, "third")`, `add(4, "fourth")`, `add(5, "fifth")`
- Check that `size()` returns 5
- Find one element: `find(3)` should return `"third"`

Changes to the BookStore System

Files to Modify: BookStore.py.

Directions:

1. Modify the constructor in `BookStore` so that it includes an additional attribute called `self.bookIndices`. Initialize it to an empty `ChainedHashTable` object. This hash table will be used to map `Book` keys to their corresponding index in `self.BookCatalogue` (i.e. it will allow us to keep track of the index where each `Book` object is located based on its key).

2. Recall that `Book` objects have attributes `key`, `title`, `group`, `rank`, and `similar`. Modify the `loadCatalog()` method so that when a `Book` gets loaded into the catalogue, a new element consisting of the `Book` key and the book's index in the catalogue is stored to the hash table. The pseudocode is as follows:

   ```
   For each row i in books.txt
       b = Book(key, title, group, rank, similar)
       bookCatalog.append(b)
       bookIndices.add(key, bookCatalog.size()-1)
   ```

   The attribute `self.bookCatalogue` should be a `DLList` as in the module 3 project.

3. Add a method to `BookStore` called `addBookByKey(self, key)` that adds the book with the given `key` to the shopping cart. *HINT*: First search the hash table `bookIndices` for the index corresponding to the given key. If the index is not `None`, add the `Book` at the given index in the `bookCatalogue` to the cart. The method must print a confirmation message after it has completed its search, using the print statement,

   ```
   print(f"addBookByKey Completed in {elapsed_time} seconds")
   ```

Changes to the Calculator System

Files to Modify: Calculator.py

Directions:
In the Module 2 project you created a method that validates if a mathematical expression is properly matched (i.e., if for every open parenthesis there exists a matching closing parenthesis).

In this assignment, you will use a `ChainedHashTable` to transform a valid expression that contains variables to an expression that contains the constant values defined for specific variables. For example, if the user specifies the values $a = 1.3$, $b = 4.2$, and $c = 2.7$ for the valid expression `((a+(b*c+d))/(a-c))`, then your calculator system will have an option to display the expression `((1.3+(4.2*2.7+d))/(1.3-2.7))`.

1. In the constructor of the `Calculator` class, initialize `self.dict` to a `ChainedHashTable` object. The hash table `self.dict` will contain the key-value pairs consisting of variables as keys and constant values for those variables as values (for example, a key `"a"` corresponding to a value `1.3`).

2. Add a new method to the `Calculator` class named `print_expression(self, exp)`. The method `print_expression(self, exp)` takes in string `exp` representing a valid mathematical expression (i.e. parentheses are matched), and prints a string where the variables in `exp` have been replaced by the values contained in `self.dict`. For example, if `calculator` is an instance of the `Calculator` class, and the user has set $a = 1.3$, $b = 4.2$, and $c = 2.7$, then

```
calculator.print_expression("((a +(b * c + d))/(a - c))")
```

must print the string `"((1.3 + (4.2 * 2.7 + d))/(1.3 - 2.7))"`.

Changes to Main

Files to Modify: main.py

Directions:

1. Modify `menu_bookstore_system()` so that it includes a new option to add a book to the shopping cart by key. Your new list of options should read as follows:

```
s FIFO shopping cart
r Random shopping cart
1 Load book catalog
2 Remove a book by index from catalog
3 Add a book by index to shopping cart
4 Remove from the shopping cart
5 Search book by infix
6 Get cart best-seller
7 Add a book by key to shopping cart
0 Return to main menu
```

If the user chooses option 7, the system should prompt for a key with the message:

```
Enter book key:
```

If the key exists, the system will add the corresponding book to the cart and display the message,

```
Added title: <Insert book title>
```

If the key does not exist, it should display the message `Book not found.`.

2. Modify `menu_calculator()` so that it includes two new options: one to introduce variable values, and another to print an expression with given variable values. Your new list of options should read as follows:

```
1 Check mathematical expression
2 Store variable values
3 Print expression with values
0 Return to main menu
```

- If the user chooses option 2, the system should...
    I. prompt the user to enter a variable and value.

        ```
        Enter a variable: <user input>
        Enter its value:  <user input>
        ```

    II. ask the user if they wish to enter another variable-value pair:

        ```
        Enter another variable? Y/N: <user input>
        ```

       (a) If the user selects `Y`, step I. is repeated.
       (b) Otherwise, the user is taken back to the calculator menu
- If the user chooses option 3, the system should...
    I. prompt the user for an expression using the message

        ```
        Introduce the mathematical expression: <user input>.
        ```

    II. check if the entered expression is valid (i.e. all parentheses are matched).
       (a) If the expression is valid continue to step III.
       (b) If the expression is invalid, display the message `Invalid expression`, and return to the top of calculator menu.
    III. display the expression with variables replaced by existing values. If no variables have been set, then the original expression without replacement is displayed.

SUBMISSION PROCESS

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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.
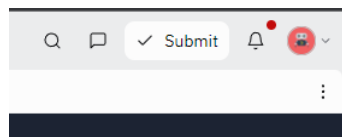
2. Modify Import Statements:

In `BookStore.py`, comment out these unnecessary imports:

1. `import BinarySearchTree`
2. `import BinaryHeap`
3. `import AdjacencyList`

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

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

...
```

3. Download and submit to CodePost.

- ChainedHashTable.py

- BookStore.py

- Calculator.py

- main.py

RUBRICS

	Full Credit 7 pts.	Partial Credit Pts. vary; See CodePost	No Credit 0 pts.
`ChainedHashTable` 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.

	Full Credit 2 pts.	Partial Credit Pts. vary; See CodePost	No Credit 0 pts.
`Calculator` 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.
`menu_calculator()`: 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.
`menu_bookstore_system()` 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.

SAMPLE RUNS

BookStore Sample Run

```
1 Calculator
2 Bookstore System
3 Palindrome Test
0 Exit/Quit
```

2

```
s FIFO shopping cart
r Random shopping cart
1 Load book catalog
2 Remove a book by index from catalog
3 Add a book by index to shopping cart
4 Remove from the shopping cart
5 Search book by infix
6 Get cart best-seller
7 Add a book by key to shopping cart
0 Return to main menu
```

1
Introduce the name of the file: books.txt
Loading 542684 books in 17.934637546539307 seconds

```
s FIFO shopping cart
r Random shopping cart
1 Load book catalog
2 Remove a book by index from catalog
3 Add a book by index to shopping cart
4 Remove from the shopping cart
5 Search book by infix
6 Get cart best-seller
7 Add a book by key to shopping cart
0 Return to main menu
```

7
Introduce the book key: 555
addBookByKey Completed in 0.0 seconds
Book not found.

```
s FIFO shopping cart
r Random shopping cart
1 Load book catalog
2 Remove a book by index from catalog
```

```
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu


7
Introduce the book key: B00005NB91
addBookByKey Completed in 0.0 seconds
Added title: Dragon Ball Z - Babidi - Dark Prince Returns

        s FIFO shopping cart
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu


7
Introduce the book key: 0855722509
addBookByKey Completed in 0.0011096000671386719 seconds
Added title: Cycling the Bush: 100 Rides in New South Wales

        s FIFO shopping cart
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu


7
Introduce the book key: 0803257201
addBookByKey Completed in 0.0 seconds
Added title: Jim Bridger, Mountain Man

        s FIFO shopping cart
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
```

```
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu


7
Introduce the book key: 0685526496
addBookByKey Completed in 0.0006206035614013672 seconds
Added title: Nikola Tesla - Lectures, Patents, Articles


        s FIFO shopping cart
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu


7
Introduce the book key: 1571810242
addBookByKey Completed in 0.0010232925415039062 seconds
Added title: Women, Family and Society in Medieval Europe: Historical Essays, 1978-1991


        s FIFO shopping cart
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu


6
getCartBestSeller returned
Nikola Tesla - Lectures, Patents, Articles
Completed in 0.0 seconds


        s FIFO shopping cart
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
```

```
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu


4
removeFromShoppingCart
Book: B00005NB91
Title: Dragon Ball Z - Babidi - Dark Prince Returns
Group: DVD
Rank: 31726 Completed in 0.0 seconds


        s FIFO shopping cart
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu


4
removeFromShoppingCart
Book: 0855722509
Title: Cycling the Bush: 100 Rides in New South Wales
Group: Book
Rank: 841117 Completed in 0.0 seconds


        s FIFO shopping cart
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu


4
removeFromShoppingCart
Book: 0803257201
Title: Jim Bridger, Mountain Man
Group: Book
Rank: 60721 Completed in 0.0 seconds


        s FIFO shopping cart
```

```
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu
```

4
removeFromShoppingCart
Book: 0685526496
Title: Nikola Tesla - Lectures, Patents, Articles
Group: Book
Rank: 1929881 Completed in 0.0 seconds

```
        s FIFO shopping cart
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu
```

4
removeFromShoppingCart
Book: 1571810242
Title: Women, Family and Society in Medieval Europe: Historical Essays, 1978-1991
Group: Book
Rank: 1484849 Completed in 0.0 seconds

```
        s FIFO shopping cart
        r Random shopping cart
        1 Load book catalog
        2 Remove a book by index from catalog
        3 Add a book by index to shopping cart
        4 Remove from the shopping cart
        5 Search book by infix
        6 Get cart best-seller
        7 Add a book by key to shopping cart
        0 Return to main menu
```

0

Calculator Sample Run

```
        1 Calculator
        2 Bookstore System
        3 Palindrome Test
        0 Exit/Quit


1


        1 Check mathematical expression
        2 Store variable values
        3 Print expression with values
        0 Return to main menu


2
Enter a variable: alpha
Enter its value: 3.2
Enter another variable? Y/N Y
Enter a variable: beta
Enter its value: -1.2
Enter another variable? Y/N Y
Enter a variable: tau
Enter its value: 10
Enter another variable? Y/N Y
Enter a variable: sigma
Enter its value: 0.02
Enter another variable? Y/N N


        1 Check mathematical expression
        2 Store variable values
        3 Print expression with values
        0 Return to main menu


3
Introduce the mathematical expression: (alpha*beta)+lambda*((2*tau)-sigma))
Invalid expression


        1 Check mathematical expression
        2 Store variable values
        3 Print expression with values
        0 Return to main menu


3
Introduce the mathematical expression: ((alpha*beta)+lambda*((2*tau)-sigma))
((3.2*-1.2)+lambda*((2*10)-0.02))
```