CAB301 ASSIGNMENT REPORT
TOOL LIBRARY SYSTEM

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Contents

Introduction

For this assignment, a software system for managing a tool library system was built. This system allows for a number of different types of tools to be stored, and lets members of the library keep track of their borrowed tools digitally. There is also a section in the program for staff of the library to manage the contents of the library, for example by adding new tools or modifying the stock of existing tools.

The implementation of the system into a C# program was fairly simple, and there were no major problems in implementing the required functionality. However, some restrictions due to the interfaces which the program had to utilise were limiting, as these interfaces could not be modified. This was an issue since some of them did not contain all of the required functionality, most notably the ToolLibrarySystem interface, which did not contain some essential functions which were needed to complete some of the requested functionality. These issues could be circumvented by creating a database class which holds the program's data. This meant that the program could interact with the data to complete any functionality which was outside the scope of the given ToolLibrarySystem interface.

In the future, with the ability to modify the interfaces, a better solution than to expose the program's data as public would be to fully flesh out the ToolLibrarySystem interface and class with more methods for accessing and manipulating the data in the system. This would remove the need to do so directly from the program's code, ensuring the data cannot be incorrectly manipulated.

This report was written as a technical description of the program, providing extra information on algorithms and testing. The report will go through the key algorithms used in the program, with an explanation and justification of each algorithm's design, a pseudocode version of each algorithm, and an analysis of each algorithm's efficiency. It will also contain a test plan for the program, which will go over and validate all the functionality of the program.

Design and Analysis of Algorithms

Top Three algorithm

Introduction

An algorithm was required to retrieve the top three most-borrowed tools in the system. The algorithm chosen was one which loops through the tools once and gets the most-borrowed tools while looping through. This was chosen rather than a sorting algorithm as it is a more efficient solution, since most sorting algorithms would have to sort the whole array before the top 3 most-borrowed tools could be selected. However, if the heap sort algorithm was used the sorting could have stopped after the three highest values were sorted. There were no challenges implementing the chosen algorithm as it was quite simple, and there are no bugs present.

Pseudocode

```
ALGORITHM TopThree(A[0..n – 1])
    // Given an array A containing the amount of times each tool has been borrowed,
    // returns the top three most-borrowed tools.
    topBorrowed ← []

    for i ← 0 to n – 1 do
        for j ← 0 to 3 do
            if not topBorrowed[j] or A[i] > topBorrowed[j] do
                for x ← 2 to j do
                    topBorrowed[x + 1] ← topBorrowed[x]

                topBorrowed[j] ← A[i]
                break

    return topBorrowed
```

Algorithm description

This algorithm takes in an array *A* containing the number of borrows for each tool in the system. The algorithm then creates an array *topBorrowed* which will store the top three most-borrowed tools. Then it loops through each tool in the array *A* and iterates three times to check against each place in the *topBorrowed* array. Then, it checks if either there's nothing in the current place, or if the times the tool has been borrowed is greater than the tool in the *topBorrowed* array at the given place. If one of these things is the case, this tool will take the current place. To do this, the tools in the *topBorrowed* array from the current place to the end of the array are shifted down one place to make room for the new value. Then, the new value is inserted at the current place. The loop then breaks, since a place has been found for the tool. This repeats until all of the tools have been looped through, and then the *topBorrowed* array is returned.

Efficiency analysis

Time complexity

Since the algorithm only loops through the tools once, it has a time complexity of **O(n)**. The basic operation in the algorithm is the comparison between *A*[*i*] and *topBorrowed*[*j*]. The worst case scenario for this algorithm would be when every tool has the same or a lower borrowed amount than the last.

This would result in the basic operation not being called for the first tool, since the first element is null, the operation being called once for the second tool, since the second element is null, twice for the third tool since the third is null, and three times for every subsequent tool. Therefore, the time complexity of the algorithm is **t(n) = 1 + 2 + 3 * ((n − 1) - 2)**, which simplifies down to **O(n)**.

Empirical analysis

For a sample worst-case scenario run of the algorithm, 5 tools were added to the system with the borrowed amounts being the same for each tool, and the implemented version of the algorithm was called with them as the input. The number of times the basic operation was called was then collected, giving a value of 9. Checking this against the formula **t(n) = 1 + 2 + 3 * ((n − 1) - 2)** gives $1 + 2 + 3 * ((5 − 1) − 2) = 9$, which matches. This confirms the time complexity of the algorithm being **O(n)**.

Further validation of the time complexity of the algorithm was done by creating a test program which calls an implentation of the algorithm for increasing amounts of tools. As visible in the graph below, the execution times collected from this program confirm that the algorithm is of linear complexity.
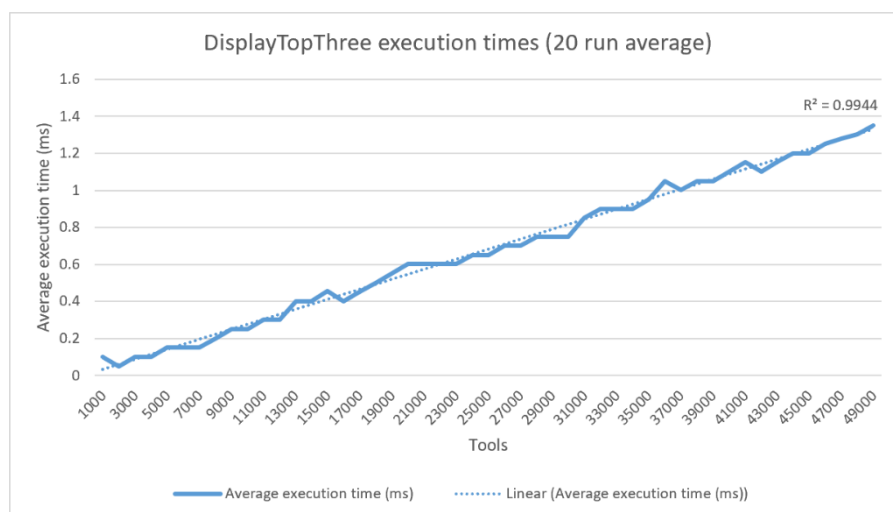

Fig 1: Execution times for the implemented top three algorithm

Space efficiency

The only variable which is created and stored in this algorithm is the *topBorrowed* array. This means the algorithm has a constant space complexity, or a space complexity of **O(1)**.

Software Test Plans and Test Results

Unit Tests

A number of unit tests were made to confirm the functionality of the system programmatically. These unit tests consisted of testing all of the functions in the ToolLibrarySystem which involved modifying data. A screenshot of the results from these tests can be seen below.
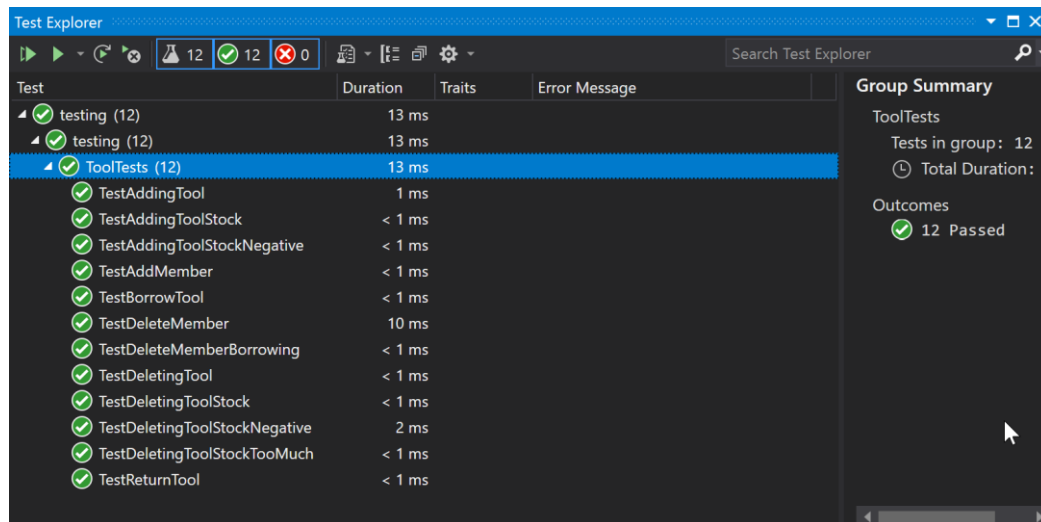

Fig 2: Results of unit tests

Tests of functionality

Screenshots for each test scenario can be found in the appendix under Test Images.

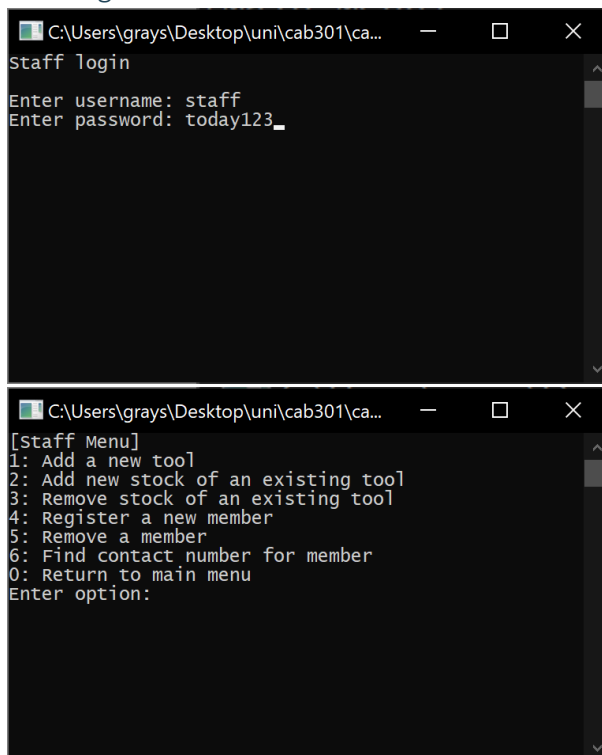| Test scenario	Test data	Expected result	Result
Menu pages			
Staff login	Username: staff Password: today123	User is logged in as staff	Pass
Staff failed login	Username: staff Password: password	User is not logged in and a message is displayed	Pass
Member login	Username: KoyGrayson PIN: 1234	Member is logged in	Pass
Member login wrong username	Username: KovGrayson PIN: 1234	Member is not logged in and a message is displayed	Pass
Member login wrong PIN	Username: KoyGrayson PIN: 2549	Member is not logged in and a message is displayed	Pass
Staff pages			
Adding a new tool	Tool name: New tool Tool quantity: 10 Category: Gardening Tools Type: Lawn Mowers	The tool is added to the system	Pass
Adding a new tool of the same name	Tool name: New tool Tool quantity: 20 Category: Gardening Tools Type: Lawn Mowers	The existing tool of the same name is found and the extra quantity is added to it	Pass

Adding tool stock	Category: Gardening Tools Type: Lawn Mowers Tool: New tool Additional stock: 12	The stock is added to the tool	Pass
Adding a negative amount of tool stock	Category: Gardening Tools Type: Lawn Mowers Tool: New tool Additional stock: -10	The stock is not added to the tool and a message is displayed	Pass
Removing tool stock	Category: Gardening Tools Type: Lawn Mowers Tool: New tool Stock to remove: 12	The stock is removed	Pass
Removing a negative amount of tool stock	Category: Gardening Tools Type: Lawn Mowers Tool: New tool Stock to remove: -10	The stock is not removed and a message is displayed	Pass
Removing too much tool stock	Category: Gardening Tools Type: Line Trimmers Tool: Bad Line Trimmer Stock to remove: 200	The stock is not removed and a message is displayed	Pass
Member registration	First name: Frank Last name: Walker Mobile number: 1300733000 PIN: 4832	The member is added	Pass
Member registration with the same name as an existing member	First name: Frank Last name: Walker Mobile number: 13007330T00 PIN: 4832	The member is not added and a message is displayed	Pass
Member removal	User: Bob Jeff	The member is removed	Pass
Finding member contact phone number	First name: Grayson Last name: Koy	The member is found and their contact number is displayed	Pass
Finding member contact number with non-existent name	First name: Grayson Last name: Jeffingtons	The member is not found and a message is displayed	Pass
Going back to main menu		Goes back to the main menu	Pass
Member pages			
Display tools by category	Category: Gardening Tools Type: Line Trimmers	The tools in the selected category of the selected type are displayed	Pass
Borrow tool from library	Category: Gardening Tools Type: Line Trimmers Tool: Bad Line Trimmer	The tool is borrowed	Pass
Trying to borrow a tool when 3 are already borrowed		A message is displayed saying you cannot borrow any more tools	Pass
Borrowing the same tool more than once	Category: Gardening Tools Type: Line Trimmers	The tool is borrowed	Pass

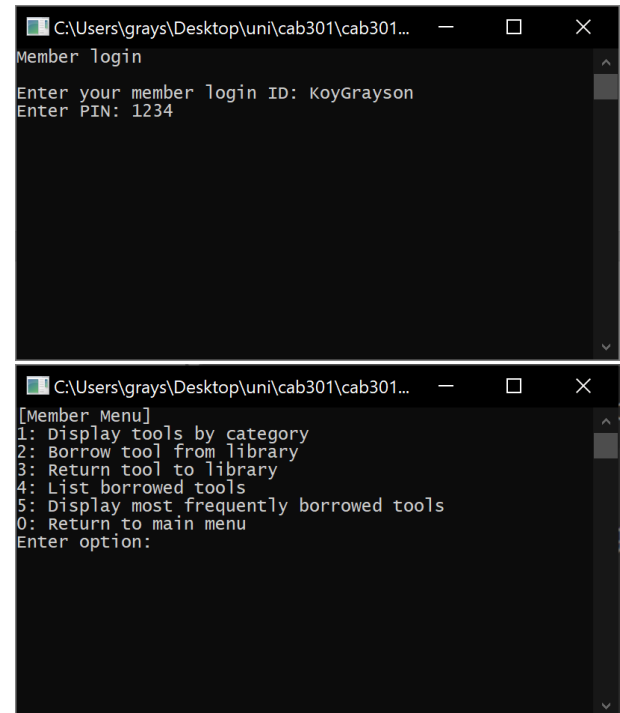|	Tool: Bad Line Trimmer		
Return tool to library	Tool: Bad Line Trimmer	The tool is returned	Pass
List borrowed tools		The member's borrowed tools are listed	Pass
List borrowed tools with no borrowed tools		A message saying that no tools have been borrowed is displayed	Pass
Display most frequently borrowed tools		The top 3 most frequently borrowed tools are displayed	Pass
Display most frequently borrowed tools when no tools have been borrowed		A message saying that no tools have been borrowed is displayed	Pass
Display most frequently borrowed tools when only 2 tools have been borrowed		The top 3 most frequently borrowed tools are displayed, with the third tool with no borrowings still being shown.	Pass
User input validation			
Incorrect page is selected in menu	Page number: 4	A message is displayed telling the user to input a valid option, and input is requested again	Pass
Incorrect entry in list selector is selected	Selected index: 100	A message is displayed telling the user to input a valid option, and input is requested again	Pass
Entering a string into an int input	Int input: gdfdg	A message is displayed telling the user to input a valid number, and input is requested again	Pass
Entering a mobile number with letters when registering	Mobile number: 4239asadsd453	A message is displayed telling the user to input only numbers, and input is requested again	Pass
Entering a PIN of incorrect length when registering	PIN: 12345	A message is displayed telling the user to input a 4-digit pin, and input is requested again	Pass

Appendix

Test images

Staff login


```
Staff login

Enter username: staff
Enter password: today123_
```



```
[Staff Menu]
1: Add a new tool
2: Add new stock of an existing tool
3: Remove stock of an existing tool
4: Register a new member
5: Remove a member
6: Find contact number for member
0: Return to main menu
Enter option:
```
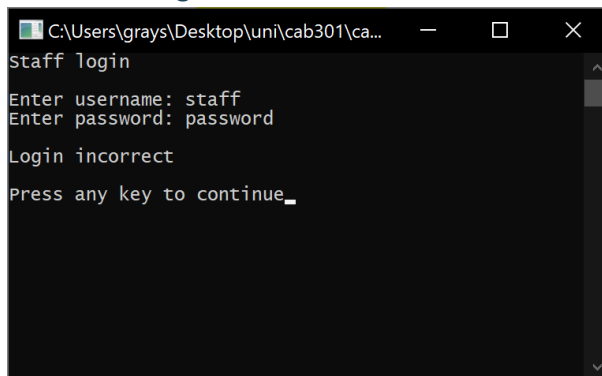
Staff failed login


```
Staff login

Enter username: staff
Enter password: password

Login incorrect

Press any key to continue_
```
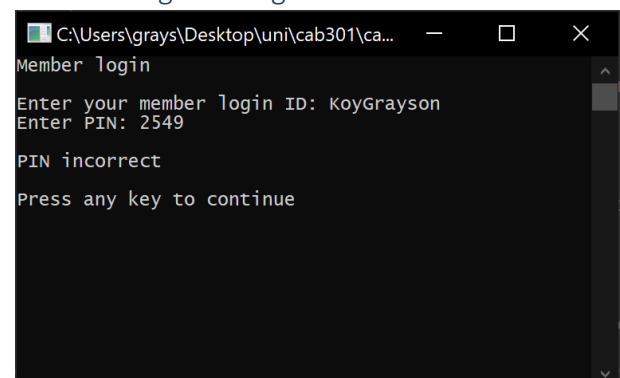
Member login


```
Member login

Enter your member login ID: KoyGrayson
Enter PIN: 1234
```



```
[Member Menu]
1: Display tools by category
2: Borrow tool from library
3: Return tool to library
4: List borrowed tools
5: Display most frequently borrowed tools
0: Return to main menu
Enter option:
```

Member login wrong username


```
Member login

Enter your member login ID: KovGrayson

Member not found

Press any key to continue_
```

Member login wrong PIN


```
Member login

Enter your member login ID: KoyGrayson
Enter PIN: 2549

PIN incorrect

Press any key to continue
```

Adding a new tool

```
Adding tool menu

Enter the name of the new tool (0 to exit): New tool

Enter the tool quantity: 10

Select tool category:
 1. Gardening Tools
 2. Flooring Tools
 3. Fencing Tools
 4. Measuring Tools
 5. Cleaning Tools
 6. Painting Tools
 7. Electronic Tools
 8. Electricity Tools
 9. Automotive Tools
Tool category (0 to exit): 1

Select tool type:
 1. Line Trimmers
 2. Lawn Mowers
 3. Hand Tools
 4. wheelbarrows
 5. Garden Power Tools
Tool type (0 to exit): 2

Tool successfully added

Press any key to continue
```

Adding a negative amount of tool stock

```
Adding tool stock menu

Select tool category:
 1. Gardening Tools
 2. Flooring Tools
 3. Fencing Tools
 4. Measuring Tools
 5. Cleaning Tools
 6. Painting Tools
 7. Electronic Tools
 8. Electricity Tools
 9. Automotive Tools
Tool category (0 to exit): 1

Select tool type:
 1. Line Trimmers
 2. Lawn Mowers
 3. Hand Tools
 4. wheelbarrows
 5. Garden Power Tools
Tool type (0 to exit): 2

Select tool to add stock for:
 1. New tool - 22/22 available
Tool (0 to exit): 1

Enter the stock to add: -10
Please enter a valid amount
Enter the stock to add:
```

Adding a new tool of the same name

```
Adding tool menu

Enter the name of the new tool (0 to exit): New tool
Enter the tool quantity: 20

Select tool category:
 1. Gardening Tools
 2. Flooring Tools
 3. Fencing Tools
 4. Measuring Tools
 5. cleaning Tools
 6. Painting Tools
 7. Electronic Tools
 8. Electricity Tools
 9. Automotive Tools
Tool category (0 to exit): 1

Select tool type:
 1. Line Trimmers
 2. Lawn Mowers
 3. Hand Tools
 4. wheelbarrows
 5. Garden Power Tools
Tool type (0 to exit): 2

Tool already exists, additional stock added (stock 10 -> 30)

Press any key to continue
```

Removing tool stock

```
Removing tool stock menu

Select tool category:
 1. Gardening Tools
 2. Flooring Tools
 3. Fencing Tools
 4. Measuring Tools
 5. Cleaning Tools
 6. Painting Tools
 7. Electronic Tools
 8. Electricity Tools
 9. Automotive Tools
Tool category (0 to exit): 1

Select tool type:
 1. Line Trimmers
 2. Lawn Mowers
 3. Hand Tools
 4. wheelbarrows
 5. Garden Power Tools
Tool type (0 to exit): 2

Select tool to remove stock for:
 1. New tool - 22/22 available
Tool (0 to exit): 1

Enter the stock to remove: 12

12 stock removed

Press any key to continue
```

Adding tool stock

```
Select tool category:
 1. Gardening Tools
 2. Flooring Tools
 3. Fencing Tools
 4. Measuring Tools
 5. Cleaning Tools
 6. Painting Tools
 7. Electronic Tools
 8. Electricity Tools
 9. Automotive Tools
Tool category (0 to exit): 1

Select tool type:
 1. Line Trimmers
 2. Lawn Mowers
 3. Hand Tools
 4. wheelbarrows
 5. Garden Power Tools
Tool type (0 to exit): 2

Select tool to add stock for:
 1. New tool - 10/10 available
Tool (0 to exit): 1

Enter the stock to add: 12

12 stock added

Press any key to continue
```

Removing a negative amount of tool stock

```
C:\Users\grays\Desktop\uni\cab301\cab301...                    —    □    ✕
Removing tool stock menu

Select tool category:
 1. Gardening Tools
 2. Flooring Tools
 3. Fencing Tools
 4. Measuring Tools
 5. Cleaning Tools
 6. Painting Tools
 7. Electronic Tools
 8. Electricity Tools
 9. Automotive Tools
Tool category (0 to exit): 1

Select tool type:
 1. Line Trimmers
 2. Lawn Mowers
 3. Hand Tools
 4. Wheelbarrows
 5. Garden Power Tools
Tool type (0 to exit): 2

Select tool to remove stock for:
 1. New tool - 10/10 available
Tool (0 to exit): 1

Enter the stock to remove: -10
Please enter a valid amount
Enter the stock to remove:
```

Removing too much tool stock

```
C:\Users\grays\Desktop\uni\cab301\cab301-assignment\cab30...    —    □    ✕
Removing tool stock menu

Select tool category:
 1. Gardening Tools
 2. Flooring Tools
 3. Fencing Tools
 4. Measuring Tools
 5. Cleaning Tools
 6. Painting Tools
 7. Electronic Tools
 8. Electricity Tools
 9. Automotive Tools
Tool category (0 to exit): 1

Select tool type:
 1. Line Trimmers
 2. Lawn Mowers
 3. Hand Tools
 4. Wheelbarrows
 5. Garden Power Tools
Tool type (0 to exit): 1

Select tool to remove stock for:
 1. Bad Line Trimmer - 100/100 available
 2. Ultra Line Trimmer - 21/21 available
 3. Luxury Line Trimmer - 47/47 available
 4. Another Line Trimmer - 55/55 available
 5. Unavailable Line Trimmer - 0/0 available
Tool (0 to exit): 1

Enter the stock to remove: 200
Quantity change for Bad Line Trimmer failed (removing too many)

Press any key to continue
```

Member registration

```
C:\Users\grays\Desktop\uni\cab301\cab301-as...                 —    □    ✕
Member registration menu

Enter the first name of the new member: Frank
Enter the last name of the new member: Walker
Enter the mobile number of the new member: 1300733000
Enter PIN: 4832

Added member Frank Walker (1300733000) successfully

Press any key to continue
```

Member registration with the same name as an existing member

```
C:\Users\grays\Desktop\uni\cab301\cab301-assignment\cab...     —    □    ✕
Member registration menu

Enter the first name of the new member: Frank
Enter the last name of the new member: Walker
Enter the mobile number of the new member: 1300733000
Enter PIN: 4832

A member with the same name already exists

Press any key to continue
```

Member removal

```
C:\Users\grays\Desktop\uni\cab301\ca...                        —    □    ✕
Member deletion menu

Select member to delete:
 1. Bob Jeff (12345678)
 2. Grayson Koy (12345678)
Member (0 to exit): 1

Deleted member Bob Jeff (12345678) successfully

Press any key to continue
```

Finding member contact phone number

```
C:\Users\grays\Desktop\uni\cab301\cab301-as...                 —    □    ✕
Member contact number finder

Enter the first name of the member: Grayson
Enter the last name of the member: Koy

Grayson Koy has the contact number 12345678

Press any key to continue
```

Finding member contact number with non-existent name

```
C:\Users\grays\Desktop\uni\cab301\cab301-assignment\cab30...   —    □    ✕
Member contact number finder

Enter the first name of the member: Grayson
Enter the last name of the member: Jeffingtons

Member not found

Press any key to continue
```

Going back to main menu

```
C:\Users\grays\Desktop\uni\cab301\cab301-as...    —    □    ×
[Main Menu]
Welcome to the Tool Library System

1: Staff Operations
2: Member Operations
0: Exit Application
Enter option: _
```

Display tools by category

```
C:\Users\grays\Desktop\uni\cab301\cab301-as...    —    □    ×
Tool display menu

Select tool category:
 1. Gardening Tools
 2. Flooring Tools
 3. Fencing Tools
 4. Measuring Tools
 5. Cleaning Tools
 6. Painting Tools
 7. Electronic Tools
 8. Electricity Tools
 9. Automotive Tools
Tool category (0 to exit): 1

Select tool type:
 1. Line Trimmers
 2. Lawn Mowers
 3. Hand Tools
 4. Wheelbarrows
 5. Garden Power Tools
Tool type (0 to exit): 1

Tools in tool type 'Line Trimmers'
1. Bad Line Trimmer - 100/100 available
2. Ultra Line Trimmer - 21/21 available
3. Luxury Line Trimmer - 47/47 available
4. Another Line Trimmer - 55/55 available
5. Unavailable Line Trimmer - 0/0 available

Press any key to continue_
```

Borrow tool from library

```
C:\Users\grays\Desktop\uni\cab301\cab301-assignment\cab30...    —    □    ×
Tool borrowing menu

Select tool category:
 1. Gardening Tools
 2. Flooring Tools
 3. Fencing Tools
 4. Measuring Tools
 5. Cleaning Tools
 6. Painting Tools
 7. Electronic Tools
 8. Electricity Tools
 9. Automotive Tools
Tool category (0 to exit): 1

Select tool type:
 1. Line Trimmers
 2. Lawn Mowers
 3. Hand Tools
 4. Wheelbarrows
 5. Garden Power Tools
Tool type (0 to exit): 1

Select tool to borrow:
 1. Bad Line Trimmer - 100/100 available
 2. Ultra Line Trimmer - 21/21 available
 3. Luxury Line Trimmer - 47/47 available
 4. Another Line Trimmer - 55/55 available
Tool (0 to exit): 1

Grayson Koy (12345678) borrowed tool Bad Line Trimmer successfully

Press any key to continue_
```

Trying to borrow a tool when 3 are already borrowed

```
C:\Users\grays\Desktop\uni\cab301\cab301-assignment\cab30...    —    □    ×
Tool borrowing menu

Cannot borrow any more tools

Press any key to continue_
```

Borrowing the same tool more than once

```
C:\Users\grays\Desktop\uni\cab301\cab301-assignment\cab30...    —    □    ×
Tool borrowing menu

Select tool category:
 1. Gardening Tools
 2. Flooring Tools
 3. Fencing Tools
 4. Measuring Tools
 5. Cleaning Tools
 6. Painting Tools
 7. Electronic Tools
 8. Electricity Tools
 9. Automotive Tools
Tool category (0 to exit): 1

Select tool type:
 1. Line Trimmers
 2. Lawn Mowers
 3. Hand Tools
 4. Wheelbarrows
 5. Garden Power Tools
Tool type (0 to exit): 1

Select tool to borrow:
 1. Bad Line Trimmer - 99/100 available
 2. Ultra Line Trimmer - 21/21 available
 3. Luxury Line Trimmer - 47/47 available
 4. Another Line Trimmer - 55/55 available
Tool (0 to exit): 1

Grayson Koy (12345678) borrowed tool Bad Line Trimmer successfully

Press any key to continue
```

Return tool to library

```
C:\Users\grays\Desktop\uni\cab301\cab301-a...    —    □    ×
Tool return menu

Select tool:
 1. Bad Line Trimmer
Tool (0 to exit): 1

Tool 'Bad Line Trimmer' returned successfully

Press any key to continue_
```

List borrowed tools

```
C:\Users\grays\Desktop\uni\cab301\cab301-a...    —    □    ×
Borrowed tools for Grayson Koy (12345678)

Grayson Koy (12345678)'s borrowed tools
1. Bad Line Trimmer

Press any key to continue
```

List borrowed tools with no borrowed tools

```
■ C:\Users\grays\Desktop\uni\cab301\cab301-a...   —   □   ×
Borrowed tools for Grayson Koy (12345678)

Grayson Koy (12345678) is not borrowing any tools

Press any key to continue_
```

Display most frequently borrowed tools

```
■ C:\Users\grays\Desktop\uni\cab301\cab30...   —   □   ×
Most frequently borrowed tools

Top 3 most frequently borrowed tools:
#1: Another Line Trimmer - 10 borrows
#2: Luxury Line Trimmer - 7 borrows
#3: Bad Line Trimmer - 4 borrows

Press any key to continue
```

Display most frequently borrowed tools when no tools have been borrowed

```
■ C:\Users\grays\Desktop\uni\cab301\cab301-assignmen...   —   □   ×
Most frequently borrowed tools

No tools have been borrowed

Press any key to continue_
```

Display most frequently borrowed tools when only 2 tools have been borrowed

```
■ C:\Users\grays\Desktop\uni\cab301\cab301-assig...   —   □   ×
Most frequently borrowed tools

Top 3 most frequently borrowed tools:
#1: Bad Line Trimmer - 4 borrows
#2: Ultra Line Trimmer - 3 borrows
#3: Luxury Line Trimmer - 0 borrows

Press any key to continue
```

Incorrect page is selected in menu

```
■ C:\Users\grays\Desktop\uni\cab301\cab301-assignment\cab30...   —   □   ×
[Main Menu]
Welcome to the Tool Library System

1: Staff Operations
2: Member Operations
0: Exit Application
Enter option: 4
Please select a valid option
Enter option: _
```

Incorrect entry in list selector is selected

```
■ C:\Users\grays\Desktop\uni\cab301\cab301-assignment\ca...   —   □   ×
Tool display menu

Select tool category:
1. Gardening Tools
2. Flooring Tools
3. Fencing Tools
4. Measuring Tools
5. Cleaning Tools
6. Painting Tools
7. Electronic Tools
8. Electricity Tools
9. Automotive Tools
Tool category (0 to exit): 100
Please select a valid option
Tool category (0 to exit): _
```

Entering a string into an int input

```
■ C:\Users\grays\Desktop\uni\cab301\cab301-assignment\cab30...   —   □   ×
Adding tool menu

Enter the name of the new tool (0 to exit): aaa

Enter the tool quantity: gdfdg
Please enter a valid number
Enter the tool quantity: _
```
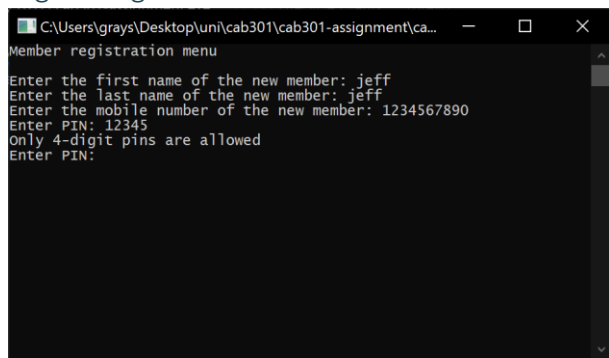
Entering a mobile number with letters when registering

```
■ C:\Users\grays\Desktop\uni\cab301\cab301-assignment\cab301-assignme...   —   □   ×
Member registration menu

Enter the first name of the new member: jeff
Enter the last name of the new member: jeff
Enter the mobile number of the new member: 4239asadsd453
Please enter only numbers
Enter the mobile number of the new member: _
```

Entering a PIN of incorrect length when registering


```
C:\Users\grays\Desktop\uni\cab301\cab301-assignment\ca...        —    □    ✕
Member registration menu

Enter the first name of the new member: jeff
Enter the last name of the new member: jeff
Enter the mobile number of the new member: 1234567890
Enter PIN: 12345
Only 4-digit pins are allowed
Enter PIN:
```