CAB301: Project Report

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1.0. Introduction

1.1. Introduction of the Project

The console application designed in this project acts as a tool library system that staff and registered members can access and edit. Staff have been given the tools to add and remove entered tools from the system, the ability to register new and remove current members, and return the contact number of a selected member. Members can view all the tools currently in the system, borrow and return up to three tools at a time, view these tools they have rented, and the also view the top three rented tools in the system.

1.2. Purpose and Structure of the Report

The purpose of this report is to present an understanding of the concepts covered in this unit and display the analysis techniques used for calculating the time efficiency of an algorithm. The pseudocode design, theoretical and empirical analysis of the algorithm required to display the top three most frequently borrowed tools has been laid out, including a snippet of the test mock-up used when undergoing the empirical analysis. The test plan for the project code and all the solutions to each test case has also been displayed in this report.

2.0. Algorithm Design and Analysis

2.1. Algorithm Design

The design for both algorithms was similar; both looping through the values in the array from index 0 to n-1. The functionality was split into two different algorithms as to keep the time complexity of determining the top three most borrowed tools efficient. By taking this approach, each time the algorithm that holds the functionality of returning the top tool searches for that tool in the array, it only needs to determine the top tool for that position, and no extra for loop would be required.

The pseudocode for GetTopTool(int position, iTool[] topTools) from the Tool class:

ALGORITHM GetTopTool(v, A[0...n-1])
      // Input: A integer n, and an array A of length n≤1.
      // Output: Returns an iTool with the largest number of borrowings for position n
          in the array.

      max ← 0
      topTool ← null
      tools ← Q
      for each *t ∈ tools* **do**
          if *v = 0 and t borrowings ≠ 0 and max = t borrowings*
              max ← t borrowings
              topTool ← t
          else if *t borrowings ≠ 0 and max ≤ t borrowings and t borrowings ≤ A[v – 1] borrowings and t name ≠ A[v – 1] name*
              max ← t borrowings
              topTool ← tool
      return *topTool*

The pseudocode for displayTopThree() from the ToolLibrarySystem class:

ALGORITHM displayTopThree()
      // Displays the top three tools added to the array

      topThree ← A[0..n-1]
      for *i ← 0 to n-1* **do**
          topTool ← P(i, topThree)
          topThree[i] ← topTool
          if *topTool = null*
              break
      for *i ← 0 to n-1* **do**
          if *topThree[1] ≠ null*
              print *(i – 1), topThree[i] name, topThree[i] borrowings*
          else
              print *All (other) tools in the system have 0 borrowings*

2.2.   Algorithm Analysis

A theoretical and empirical was performed on the algorithm designed to determine its time efficiency.

2.2.1. Theoretical Analysis

The algorithms created to solve the computation problem of displaying the top three borrowed tools, as calculated below, was expected to have the efficiency class O(n). From looking at the algorithms created – as neither use nested for loops and instead use one for/for each loop and if else statements – O(n) was the expected efficiency class before performing any calculations.

As both algorithms use the same concept, a single theoretical analysis can be performed that will apply to them both.

The theoretical analysis of the algorithms:

The basic operation of these algorithms is looping from 0 to n-1.

$$\sum_{i=l}^{u} 1 = u - l + 1, \qquad l \leq u$$

Using the above summation manipulation rule from lecture two slide eleven, this algorithms' basic operation would look like:

$$\sum_{0}^{n-1} 1 = (n-1) - (0) + 1, \qquad 0 \leq n-1$$
$$= n - 1 + 1$$
$$= n$$

Therefore, as expected, it can be concluded that these algorithms follow the basic structure of an O(n) efficiency class.

2.2.2. Empirical Analysis

The empirical analysis was done by testing the time complexity of the displayTopThree() algorithm, as it calls the GetTopTool(int position, iTool[] topTools) within it.

A stopwatch variable was used outside the for each loop to time the computations as the number of members in the library was increased by one. A small test sample of 3-28 tools added was chosen due to complexity of adding multiple tools to an array manually as each needed to have unique names and, ideally, different numbers of borrowings to sort by. Three was chosen as the starting value as that would be the ideal number of tools existing in the system to use the full functionality of the algorithm.

The data received was seen to match a linear trendline, characteristic of O(n). When performing the calculations, it could be seen that the ratio of t(2n)/t(n) was always less than 2, averaging at around 1.453348. While this value is less than 2 - meaning the algorithm is more efficient than O(n) - we know that as the data follows a linear representation, the time taken to perform the calculation is not constant, therefore it cannot be O(1), implying the efficiency class of this algorithm is O(n).

Due to this small test sample, and to CPU throttling as the test program first compiled, the test results are slightly more skewed than desired for a perfect analysis to take place, though they are accurate enough to give the expected efficiency class.

n	time	t(2n)/t(n)
3	0.6317332	
4	0.771577	
5	0.6682071	t(2n)/t(n)
6	0.7416429	1.173981
7	0.8096471	
8	0.9499916	
9	0.909391	
10	1.0738448	
11	1.1384573	t(2n)/t(n)
12	1.1688795	1.576068
13	1.2510397	
14	1.2998151	
15	1.415735	
16	1.3996776	
17	1.5665427	
18	1.5944369	
19	1.6582268	
20	1.6645496	
21	1.6679211	
22	1.8927964	
23	2.1214729	t(2n)/t(n)
24	2.0141686	1.609996
25	1.9867069	
26	2.242869	
27	2.2875611	
28	2.2322825	

Linear - O(n) $y = 0.0683x + 0.3713$ $R^2 = 0.9825$
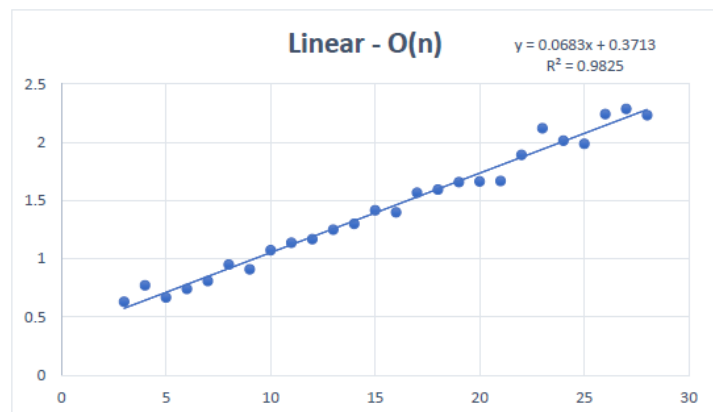
Figure 1: Empirical Testing Data and Results

```
int numTools = test.toolList.Count;
Tool topTool;
Tool[] topThree = new Tool[3];

double[] times = new double[testlist.Count];

Stopwatch timer = new Stopwatch();

int testnum = 1000000;

for (int i = 0; i < testlist.Count - 1; i++)
{
    for (int t = 0; t < testnum; t++)
    {
        timer.Start();
        for (int counter = 0; counter < 3; counter++)
        {
            // Get the top tool for the current poistion (1st, 2nd, 3rd)
            topTool = test.GetTopTool(counter, topThree);

            // Add it to the array
            topThree[counter] = topTool;
        }
        timer.Stop();

        times[i] += timer.Elapsed.TotalMilliseconds;
        timer.Reset();
    }
    test.toolList.Add(testlist[i]);
}


foreach (double t in times)
{
    Console.WriteLine("TIME: " + t/testnum * 1000);
}
```

Figure 2: Snippet of Test Code for Empirical Testing

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3.0. Software Test Plan

The testing for the application was done manually; depending on the input type for each menu different approaches were taken, though most were very similar. For example, any tests that required an integer to be inputted, the string "qwerty" was used to ensure that non-integer inputs would not be accepted.

3.1. Main Menu Testing

Functionality included selecting the staff login, member login, and exiting the console.

	Test Cases	Inputs (; used to separate inputs entered)
1	Enter invalid input	q
2	Enter input not in range	5
3	Enter a valid input of either 1 or 2	1
4	Enter a valid input of 0 to close console	0

```
Welcome to the Tool Library
==========Main Menu==========
1. Staff Login
2. Member Login
0. Exit
=============================

Please make a selection (1-2, or 0 to exit): Q

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-2, or 0 to return to main menu): 5

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-2, or 0 to return to main menu): 1

==========Staff Login==========
Username (staff):
```
Screenshot 1: Test Cases One-Three Main Menu

3.1.1. Staff Login
The staff login was built into the code using the username "staff" and password "today123".

	Test Cases	Inputs (; used to separate inputs entered)
1	Incorrect username **AND** Incorrect password; Retry – No	qwerty; qwerty; N
2	Correct username **AND** Incorrect password; Retry - Yes	staff; qwerty; Y
3	Incorrect username **AND** Correct password; Retry - Yes	qwerty; today123; Y
4	Correct username **AND** Correct password	staff; today123

```
Welcome to the Tool Library
==========Main Menu===========
1. Staff Login
2. Member Login
0. Exit
==============================

Please make a selection (1-2, or 0 to exit): 1

==========Staff Login===========
Username (staff): qwerty
Password (today123): qwerty

====LOGIN INVALID====
Would you like to retry? (Y/N): N

Welcome to the Tool Library
==========Main Menu===========
1. Staff Login
2. Member Login
0. Exit
==============================

Please make a selection (1-2, or 0 to exit):
```
Screenshot 2: Test Case One Staff Login

```
Welcome to the Tool Library
==========Main Menu===========
1. Staff Login
2. Member Login
0. Exit
==============================

Please make a selection (1-2, or 0 to exit): 1

==========Staff Login===========
Username (staff): qwerty
Password (today123): qwerty

====LOGIN INVALID====
Would you like to retry? (Y/N): Y

==========Staff Login===========
Username (staff): staff
Password (today123): qwerty

====LOGIN INVALID====
Would you like to retry? (Y/N): Y

==========Staff Login===========
Username (staff): qwerty
Password (today123): today123

====LOGIN INVALID====
Would you like to retry? (Y/N): Y

==========Staff Login===========
Username (staff): staff
Password (today123): today123

Welcome to the Tool Library
===============Staff Menu===============
1. Add a new tool
2. Add new pieces of an existing tool
3. Remove some pieces of a tool
4. Register a new member
5. Remove a member
6. Find the contact number of a member
0. Return to main menu
========================================

Please make a selection (1-6, or 0 to return to main menu):
```
Screenshot 3: Test Cases Two-Four Staff Login

3.1.2. Member Login

The member login would be accepted if the first name, last name, and password of a registered member were inputted. First name and last name capitalisation does not matter, password capitalisation does.

	Test Cases	Inputs (; used to separate inputs entered)
1	Non-existent credentials; Retry - No	qwerty; qwerty; qwerty; N
2	Valid first name **AND** Invalid last name, password; Retry - Yes	Ash; qwerty; qwerty; Y
3	Valid last name **AND** Invalid first name, password; Retry - Yes	qwerty; Jane; qwerty; Y
4	Valid password **AND** Invalid first name, last name; Retry - Yes	qwerty; qwerty; 1234; Y
5	Valid credentials entered	Ash; Jane; 1234

```
Welcome to the Tool Library
==========Main Menu===========
1. Staff Login
2. Member Login
0. Exit
==============================

Please make a selection (1-2, or 0 to exit): 2

==========Member Login==========
First name: qwerty
Last name: qwerty
Password: qwerty

====LOGIN INVALID====
Would you like to retry? (Y/N): N

Welcome to the Tool Library
==========Main Menu===========
1. Staff Login
2. Member Login
0. Exit
==============================

Please make a selection (1-2, or 0 to exit):
```

Screenshot 4: Test Case One Member Login

```
==========Member Login==========
First name: Ash
Last name: qwerty
Password: qwerty

====LOGIN INVALID====
Would you like to retry? (Y/N): Y

==========Member Login==========
First name: qwerty
Last name: Jane
Password: qwerty

====LOGIN INVALID====
Would you like to retry? (Y/N): Y

==========Member Login==========
First name: qwerty
Last name: qwerty
Password: 1234

====LOGIN INVALID====
Would you like to retry? (Y/N): Y

==========Member Login==========
First name: Ash
Last name: Jane
Password: 1234

Welcome to the Tool Library
==============Member Menu===============
1. Display all the tools of a tool type
2. Borrow a tool
3. Return a tool
4. List all the tools that I am renting
5. Display top three (3) most frequently rented tools
0. Return to main menu
==========================================

Please make a selection (1-5, or 0 to return to main menu):
```

Screenshot 5: Test Cases Two-Five Member Login

3.1.3. Exit Console

The exist console input was tested with the initial main menu tests – no screenshot as closes console.

3.2.   Staff Menu Testing

Functionality included selecting all the different options the staff member has.

	Test Cases	Inputs (; used to separate inputs entered)
1	Invalid input	q
2	Input not in range	7
3	Valid input between 1-6 inclusive	4
4	Valid input of 0 to return to main	0
5	**Tool Category/Type Selection** – Return to staff menu.	0

```
================Staff Menu================
1. Add a new tool
2. Add new pieces of an existing tool
3. Remove some pieces of a tool
4. Register a new member
5. Remove a member
6. Find the contact number of a member
0. Return to main menu
=========================================

Please make a selection (1-6, or 0 to return to main menu): Q

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-6, or 0 to return to main menu): 7

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-6, or 0 to return to main menu): 4

Welcome to the Tool Library
==============Members==============
1. Jane, Phil, 24232525
2. Ash, Jane, 123456789
3. Jamie, Campbell, 32523525
=========================================

========Register New Member========
(Leave all fields blank if you wish to return to the previous menu.)
First Name:
```

Screenshot 6: Test Cases One-Three Staff Menu

```
Welcome to the Tool Library
================Staff Menu================
1. Add a new tool
2. Add new pieces of an existing tool
3. Remove some pieces of a tool
4. Register a new member
5. Remove a member
6. Find the contact number of a member
0. Return to main menu
=========================================

Please make a selection (1-6, or 0 to return to main menu): 0

Welcome to the Tool Library
===========Main Menu===========
1. Staff Login
2. Member Login
0. Exit
=========================================

Please make a selection (1-2, or 0 to exit):
```

Screenshot 7: Test Case Four Staff Menu

```
Please make a selection (1-6, or 0 to return to main menu): 1

Welcome to the Tool Library
========Tool Categories=========
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
0. Return to staff menu
=========================================

Please make a selection (1-9, or 0 to return to staff menu): 0

Welcome to the Tool Library
================Staff Menu================
1. Add a new tool
2. Add new pieces of an existing tool
3. Remove some pieces of a tool
4. Register a new member
5. Remove a member
6. Find the contact number of a member
0. Return to main menu
=========================================

Please make a selection (1-6, or 0 to return to main menu):
```

Screenshot 8: Test Case Five Staff Menu

3.2.1. Add New Tool

This menu directed the user through the tool categories and tool types before a user could be added. (Test cases for return to staff menu when choosing category/type is covered above.)

	Test Cases	Inputs (; used to separate inputs entered)
1	Choose category and type	1; 1
2	Add tool with invalid quantity format	Hammer; qwerty
3	Add tool with valid details	Hammer; 5
4	Leave fields blank to return previous menu	ENTER through fields

```
Please make a selection (1-6, or 0 to return to main menu): 1

Welcome to the Tool Library
=========Tool Categories=========
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
0. Return to staff menu
=================================

Please make a selection (1-9, or 0 to return to staff menu): 1

Welcome to the Tool Library
=========Gardening Tools=========
1. Line Trimmers
2. Lawn Mowers
3. Hand Tools
4. Wheelbarrows
5. Garden Power Tools
0. Return to staff menu
=================================

Please make a selection (1-5, or 0 to return to staff menu): 1

Welcome to the Tool Library
==============Tools==============
1. Saw,  4
2. Screwdriver,  1
=================================

=======Add New Tool=======
(Leave all fields blank if you wish to return to the previous menu.)
Name: Hammer
Quantity: qwerty
=========================

== I'm sorry, your input was not recognised. Please enter a valid input. ==

=======Add New Tool=======
(Leave all fields blank if you wish to return to the previous menu.)
Name: Hammer
Quantity: 5
=========================

Welcome to the Tool Library
==============Tools==============
1. Saw,  4
2. Screwdriver,  1
3. Hammer,  5
=================================
Press any key to return to previous menu...
```

Screenshot 9: Test Cases One-Three Add New Tool

```
Welcome to the Tool Library
==============Tools==============
1. Saw,  4
2. Screwdriver,  1
3. Hammer,  5
=================================

=======Add New Tool=======
(Leave all fields blank if you wish to return to the previous menu.)
Name:
Quantity:
=========================

Welcome to the Tool Library
================Staff Menu================
1. Add a new tool
2. Add new pieces of an existing tool
3. Remove some pieces of a tool
4. Register a new member
5. Remove a member
6. Find the contact number of a member
0. Return to main menu
==========================================

Please make a selection (1-6, or 0 to return to main menu):
```

Screenshot 10: Test Case Four Add New Tool

3.2.2. Add New Pieces of an Existing Tool

As with adding a new tool, this menu again directed the user through the tool categories and tool types before a user could select an existing tool and add quantity to it.

	Test Cases	Inputs (; used to separate inputs entered)
1	Return to staff menu when selecting a tool	0
2	Invalid quantity format	qwerty
3	Negative quantity	-1
4	Accepted quantity format	5

```
Please make a selection (1-5, or 0 to return to staff menu): 1

Welcome to the Tool Library
==============Tools==============
1. Saw,  3
2. Screwdriver,  6
================================

Please make a selection (1-2, or 0 to return to staff menu): 0

Welcome to the Tool Library
==============Staff Menu=================
1. Add a new tool
2. Add new pieces of an existing tool
3. Remove some pieces of a tool
4. Register a new member
5. Remove a member
6. Find the contact number of a member
0. Return to main menu
=========================================

Please make a selection (1-6, or 0 to return to main menu):
```
Screenshot 11: Test Case One Add Tool Pieces

```
Please make a selection (1-5, or 0 to return to staff menu): 1

Welcome to the Tool Library
==============Tools==============
1. Saw,  3
2. Screwdriver,  6
================================

Please make a selection (1-2, or 0 to return to staff menu): 1

==============================Add Tool Pieces==============================
Name: Saw, Quantity: 4, Avalible Quantity: 3, No. Borrowings: 1

AddQuantity: qwerty

== I'm sorry, your input was not recognised. Please enter a valid input. ==

AddQuantity: -1

== I'm sorry, your input was not recognised. Please enter a valid input. ==

AddQuantity: 0

== I'm sorry, your input was not recognised. Please enter a valid input. ==

AddQuantity: 5

Name: Saw, Quantity: 9, Avalible Quantity: 8, No. Borrowings: 1
==========================================================================
Press any key to return to previous menu...

Welcome to the Tool Library
==============Staff Menu=================
1. Add a new tool
2. Add new pieces of an existing tool
3. Remove some pieces of a tool
4. Register a new member
5. Remove a member
6. Find the contact number of a member
0. Return to main menu
=========================================

Please make a selection (1-6, or 0 to return to main menu):
```
Screenshot 12: Test Cases Two-Four Add Tool Pieces

3.2.3. Remove Some Pieces of a Tool

This menu acted the same as the add some pieces of a tool menu, just allowed the user to remove quantity rather than add quantity.

	Test Cases	Inputs (; used to separate inputs entered)
1	Invalid delete quantity	qwerty
2	Negative delete quantity	-1
3	Valid delete quantity	2
4	Delete quantity higher than original quantity	10

```
Please make a selection (1-5, or 0 to return to staff menu): 1

Welcome to the Tool Library
=============Tools==============
1. Saw,  3
2. Screwdriver,  1
===============================

Please make a selection (1-2, or 0 to return to staff menu): 1

===========================Add Tool Pieces===========================
Name: Saw, Quantity: 4, Avalible Quantity: 3, No. Borrowings: 1

DeleteQuantity: qwerty

== I'm sorry, your input was not recognised. Please enter a valid input. ==

DeleteQuantity: -1

== I'm sorry, your input was not recognised. Please enter a valid input. ==

DeleteQuantity: 2

Name: Saw, Quantity: 2, Avalible Quantity: 1, No. Borrowings: 1
=====================================================================
Press any key to return to previous menu...

Welcome to the Tool Library
===============Staff Menu================
1. Add a new tool
2. Add new pieces of an existing tool
3. Remove some pieces of a tool
4. Register a new member
5. Remove a member
6. Find the contact number of a member
0. Return to main menu
=========================================

Please make a selection (1-6, or 0 to return to main menu):
```

Screenshot 13: Test Cases One-Three Delete Tool Pieces

```
Please make a selection (1-5, or 0 to return to staff menu): 1

Welcome to the Tool Library
=============Tools==============
1. Saw,  1
2. Screwdriver,  1
===============================

Please make a selection (1-2, or 0 to return to staff menu): 1

===========================Add Tool Pieces===========================
Name: Saw, Quantity: 2, Avalible Quantity: 1, No. Borrowings: 1

DeleteQuantity: 10

== The entered quantity exceeds the current quantity of the tool in the library. ==

Name: Saw, Quantity: 2, Avalible Quantity: 1, No. Borrowings: 1
=====================================================================
Press any key to return to previous menu...

Welcome to the Tool Library
===============Staff Menu================
1. Add a new tool
2. Add new pieces of an existing tool
3. Remove some pieces of a tool
4. Register a new member
5. Remove a member
6. Find the contact number of a member
0. Return to main menu
=========================================

Please make a selection (1-6, or 0 to return to main menu):
```

Screenshot 14: Test Case Four Delete Tool Pieces

3.2.4. Register a New Member

When registering a member, you cannot register an existing member or use the same contact number that another member has.

	Test Cases	Inputs (; used to separate inputs entered)
1	Invalid member detail format	qwerty; qwerty; qwerty; qwerty
2	Invalid member - existing names	Ash; Jane; 123456789; 1234
3	Valid member - existing first name	Jane; Smith; 123456789; 1234
4	Invalid member - existing contact number	Kelly; Smith; 123456789; asdfgh
5	Valid new member	Kelly; Kane; 0987654321; 1s2d3f4g
6	Leave fields blank	ENTER through fields

```
Please make a selection (1-6, or 0 to return to main menu): 4

Welcome to the Tool Library
=============Members=============
1. Jane, Phil, 24232525
2. Ash, Jane, 2246454
3. Jamie, Campbell, 32523525
================================

=======Register New Member=======
First Name: qwerty
Last Name: qwerty
Contact Number: qwerty
PIN: qwerty
================================

== I'm sorry, your input was not recognised. Please enter a valid input. ==

=======Register New Member=======
First Name: Ash
Last Name: Jane
Contact Number: 123456789
PIN: 1234
================================

== Cannot register member, information added matches a current members information. ==

Welcome to the Tool Library
=============Members=============
1. Jane, Phil, 24232525
2. Ash, Jane, 2246454
3. Jamie, Campbell, 32523525
================================
Press any key to return to previous menu...
```

Screenshot 15: Test Cases One and Two Register Member

```
Please make a selection (1-6, or 0 to return to main menu): 4

Welcome to the Tool Library
=============Members=============
1. Jane, Phil, 24232525
2. Ash, Jane, 2246454
3. Jamie, Campbell, 32523525
================================

=======Register New Member=======
First Name: Jane
Last Name: Smith
Contact Number: 123456789
PIN: 1234
================================

Welcome to the Tool Library
=============Members=============
1. Jane, Phil, 24232525
2. Ash, Jane, 2246454
3. Jamie, Campbell, 32523525
4. Jane, Smith, 123456789
================================
Press any key to return to previous menu...
```

Screenshot 16: Test Case Three Register Member

Screenshot 17: Test Case Four Register Member

Screenshot 18: Test Case Five Register Member

Screenshot 19: Test Case Six Register Member

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3.2.5. Remove a Member

The member selected to remove can only be removed if they are not currently borrowing any tools.

	Test Cases	Inputs (; used to separate inputs entered)
1	Selection input out of range	5
2	Valid selection input; Do not delete	3; N
3	Valid selection input; Delete – Member borrowing tools	3; Y
4	Valid selection input; Delete – Member not borrowing tools	1; Y

```
Please make a selection (1-6, or 0 to return to main menu): 5

Welcome to the Tool Library
==============Members==============
1. Jane, Phil, 24232525
2. Ash, Jane, 123456789
3. Jamie, Campbell, 32523525
==================================

Please make a selection (1-3, or 0 to return to staff menu): 5

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-3, or 0 to return to main menu): 3

============================Remove Registered Member============================
Member Selected: Jamie, Campbell, 32523525

Are you sure you want to delete this member?(Y/N): N

Welcome to the Tool Library
==============Members==============
1. Jane, Phil, 24232525
2. Ash, Jane, 123456789
3. Jamie, Campbell, 32523525
==================================

Please make a selection (1-3, or 0 to return to staff menu): 3

============================Remove Registered Member============================
Member Selected: Jamie, Campbell, 32523525

Are you sure you want to delete this member?(Y/N): Y

== This member is currently borrowing tools, cannot delete them from system. ==

Welcome to the Tool Library
==============Members==============
1. Jane, Phil, 24232525
2. Ash, Jane, 123456789
3. Jamie, Campbell, 32523525
==================================
Press any key to return to previous menu...
```

Screenshot 20: Test Cases One-Three Remove Member

```
Please make a selection (1-6, or 0 to return to main menu): 5

Welcome to the Tool Library
==============Members==============
1. Jane, Phil, 24232525
2. Ash, Jane, 123456789
3. Jamie, Campbell, 32523525
==================================

Please make a selection (1-3, or 0 to return to staff menu): 3

============================Remove Registered Member============================
Member Selected: Jamie, Campbell, 32523525

Are you sure you want to delete this member?(Y/N): Y

Welcome to the Tool Library
==============Members==============
1. Jane, Phil, 24232525
2. Ash, Jane, 123456789
==================================
Press any key to return to previous menu...
```

Screenshot 21: Test Case Four Remove Member

3.2.6. Find the Contact Number of a Member

Select a member and display their contact information.

	Test Cases	Inputs (; used to separate inputs entered)
1	Selection input out of range	6
2	Valid selection	1

```
Please make a selection (1-6, or 0 to return to main menu): 6

Welcome to the Tool Library
=============Members================
1. Jane, Phil, 24232525
2. Ash, Jane, 2246454
3. Jamie, Campbell, 32523525
====================================

Please make a selection (1-3, or 0 to return to staff menu): 6

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-3, or 0 to return to main menu): 1

===============Get Contact Number================
Contact Number of Jane Phil: 24232525

====================================================
Press any key to return to previous menu...
```
Screenshot 22: Test Cases One and Two Find Contact

3.3. Member Menu Testing

Functionality included selecting all the different options the logged in member has.

Test Cases		Inputs (; used to separate inputs entered)
1	Enter Input not in range.	7
2	Enter a valid input between 1-5 inclusive	4
3	Enter a valid input of 0 to return to main	0

```
Welcome to the Tool Library
==============Member Menu==============
1. Display all the tools of a tool type
2. Borrow a tool
3. Return a tool
4. List all the tools that I am renting
5. Display top three (3) most frequentely rented tools
0. Return to main menu
=======================================

Please make a selection (1-5, or 0 to return to main menu): 7

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-5, or 0 to return to main menu): 4

Welcome to the Tool Library
=============Enter Contact Number=============
Please enter your contact number:
```

Screenshot 23: Test Cases One and Two Member Menu

```
Welcome to the Tool Library
==============Member Menu==============
1. Display all the tools of a tool type
2. Borrow a tool
3. Return a tool
4. List all the tools that I am renting
5. Display top three (3) most frequentely rented tools
0. Return to main menu
=======================================

Please make a selection (1-5, or 0 to return to main menu): 0

Welcome to the Tool Library
==========Main Menu==========
1. Staff Login
2. Member Login
0. Exit
==============================

Please make a selection (1-2, or 0 to exit):
```

Screenshot 24: Test Case Three Member Menu

3.3.1. Display All Tools of a Tool Type

Member selects the category and type and the list of tools is displayed.

IMPORTANT The method **displayTools(string aToolType)** in the **interface iToolLibrarySystem** was **changed** to **displayTools(int aToolType)**. The reasoning for this is that integer representations of the tool type had been used throughout all other sections of the code.

	Test Cases	Inputs (; used to separate inputs entered)
1	Valid selections made	1; 1
2	Invalid input for category selection	q
3	Selected type out of range; Invalid input for selection	9; q

```
Welcome to the Tool Library
==============Member Menu===============
1. Display all the tools of a tool type
2. Borrow a tool
3. Return a tool
4. List all the tools that I am renting
5. Display top three (3) most frequently rented tools
0. Return to main menu
========================================

Please make a selection (1-5, or 0 to return to main menu): 1

Welcome to the Tool Library
=========Tool Categories=========
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
0. Return to member menu
================================

Please make a selection (1-9, or 0 to return to member menu): 1

Welcome to the Tool Library
=========Gardening Tools=========
1. Line Trimmers
2. Lawn Mowers
3. Hand Tools
4. Wheelbarrows
5. Garden Power Tools
0. Return to member menu
================================

Please make a selection (1-5, or 0 to return to member menu): 1


Welcome to the Tool Library
==============Tools==============
1. Saw,   3
2. Screwdriver,  1
================================
Press any key to return to previous menu...
```

Screenshot 25: Test Case One Display Tools

```
Please make a selection (1-5, or 0 to return to main menu): 1

Welcome to the Tool Library
=========Tool Categories=========
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
0. Return to member menu
================================

Please make a selection (1-9, or 0 to return to member menu): Q

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-9, or 0 to return to main menu): 1

Welcome to the Tool Library
=========Gardening Tools=========
1. Line Trimmers
2. Lawn Mowers
3. Hand Tools
4. Wheelbarrows
5. Garden Power Tools
0. Return to member menu
================================

Please make a selection (1-5, or 0 to return to member menu): 9

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-5, or 0 to return to main menu): Q

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-5, or 0 to return to main menu): 1


Welcome to the Tool Library
==============Tools==============
1. Saw,   3
2. Screwdriver,  1
================================
Press any key to return to previous menu...
```

Screenshot 26: Test Cases Two and Three Display Tools

N10477659

Ashley Phillips

3.3.2. Borrow a Tool

Input tool name to borrow. If it exists, the member successfully borrows a tool.

	Test Cases	Inputs (; used to separate inputs entered)
1	Invalid inputs	qwerty; qwerty
2	Valid tool name, invalid quantity	Saw; qwerty
3	Non-existent tool name, valid quantity	qwerty; 1
4	Valid inputs, will cause user to borrow over 3 tools	Saw; 4
5	Valid inputs	Saw; 3
6	Valid inputs, already borrowing 3 tools	Saw; 1
7	Leave all fields blank	ENTER through fields

```
Please make a selection (1-5, or 0 to return to main menu): 2

Welcome to the Tool Library
==============Borrow Tool==============
(Leave all fields blank if you wish to return to the previous menu.)
Tool Name: qwerty
Quantity to Borrow: qwerty

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Tool Name: Saw
Quantity to Borrow: qwerty

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Tool Name: qwerty
Quantity to Borrow: 1

== Tool does not exist in library. ==

Tool Name: Saw
Quantity to Borrow: 4

== You cannot borrow more than three (3) tools at a time. ==

Tool Name: Saw
Quantity to Borrow: 3

== Tool was successfully borrowed! ==

=======================================
Press any key to return to previous menu...

Welcome to the Tool Library
==============Member Menu===============
1. Display all the tools of a tool type
2. Borrow a tool
3. Return a tool
4. List all the tools that I am renting
5. Display top three (3) most frequently rented tools
0. Return to main menu
=======================================

Please make a selection (1-5, or 0 to return to main menu): 2

Welcome to the Tool Library
==============Borrow Tool==============
(Leave all fields blank if you wish to return to the previous menu.)
Tool Name: Saw
Quantity to Borrow: 1

==Already borrowing 3 tools, cannot borrow any more==
```

Screenshot 27: Test Cases One-Six Borrow Tool

```
Welcome to the Tool Library
==============Borrow Tool==============
(Leave all fields blank if you wish to return to the previous menu.)
Tool Name:
Quantity to Borrow:

Welcome to the Tool Library
==============Member Menu===============
1. Display all the tools of a tool type
2. Borrow a tool
3. Return a tool
4. List all the tools that I am renting
5. Display top three (3) most frequently rented tools
0. Return to main menu
=======================================

Please make a selection (1-5, or 0 to return to main menu):
```

Screenshot 28: Test Case Seven Borrow Tool

3.3.3. Return a Tool

Select a tool to return. If the member is not borrowing any tools, they will be told and then be directed to leave the menu.

Test Cases		Inputs (; used to separate inputs entered)
1	Invalid input	q
2	Input out of range	7
3	Select tool; Do not return	1; N
4	Select tool; Return	1; Y
5	Not renting any tools	-

```
Please make a selection (1-5, or 0 to return to main menu): 3

Welcome to the Tool Library
================Tools Renting=================
1. Saw
2. Hammer
3. Screwdriver
==============================================

Please make a selection (1-3, or 0 to return to member menu): Q

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-3, or 0 to return to main menu): 7

== I'm sorry, your input was not recognised. Please enter a valid input. ==

Please make a selection (1-3, or 0 to return to main menu): 1

================Return Borrowed Tool=================
Tool Selected: Saw

Are you sure you want to return this tool?(Y/N): N

Welcome to the Tool Library
================Tools Renting=================
1. Saw
2. Hammer
3. Screwdriver
==============================================

Please make a selection (1-3, or 0 to return to member menu): 1

================Return Borrowed Tool=================
Tool Selected: Saw

Are you sure you want to return this tool?(Y/N): Y

Welcome to the Tool Library
================Tools Renting=================
1. Hammer
2. Screwdriver
3.
==============================================
Press any key to return to previous menu...
```

Screenshot 29: Test Cases One-Four Return Tool

```
Please make a selection (1-5, or 0 to return to main menu): 4

Welcome to the Tool Library
==============Enter Contact Number==============
(Leave field blank if you wish to return to the previous menu.)
Please enter your contact number: 123456789
==============================================

Welcome to the Tool Library
================Tools Renting=================
=== You are currently not renting any tools ===
==============================================
Press any key to return to previous menu...
```

Screenshot 30: Test Case Five Return Tool

3.3.4. List All the Tools Member is Currently Renting

If the member is renting tools, the tools renting will be display. If they are not renting any tools, the console will tell the member they are not renting any tools.

	Test Cases	Inputs (; used to separate inputs entered)
1	Invalid contact number	qwerty
2	Incorrect contact number	123
3	Valid contact number when not renting	123456789
4	Valid contact number when renting 1	123456789
5	Valid contact number when renting 3	123456789
6	Valid contact number when renting 3 of the same tool	123456789

Screenshot 31: Test Cases One-Three List Tools Borrowing

Screenshot 32: Test Case Four List Tools Borrowing

Screenshot 33: Test Case 5 List Tools Borrowing

Screenshot 34: Test Case Six List Tools Borrowing

3.3.5. Display Top Three Most Frequently Rented Tools

If tools have been borrowed, they will show up here (unless they are not in the top three). If not tools have been borrowed, or there are no tools in the system, the user will told and no tools will be displayed. The only test inputs required were to borrow tools before entering this menu.

	Test Cases	Inputs (; used to separate inputs entered)
1	3 top tools exist	-
2	1 top tools exist – all others 0 borrowings	-
3	No top tool exists – all tools 0 borrowings	-
4	No tools in the system	-

```
Please make a selection (1-5, or 0 to return to main menu): 5

Welcome to the Tool Library
==============Top Three Tools==============
1. Saw, 4 borrowings
2. Hammer, 2 borrowings
3. Screwdriver, 2 borrowings
========================================
Press any key to return to previous menu...
```
Screenshot 35: Test Case One Display Top Three

```
Please make a selection (1-5, or 0 to return to main menu): 5

Welcome to the Tool Library
==============Top Three Tools==============
1. Saw, 2 borrowings

== All (other) tools in the system have 0 borrowings. ==

========================================
Press any key to return to previous menu...
```
Screenshot 36: Test Case Two Display Top Three

```
Welcome to the Tool Library
==============Top Three Tools==============

== All (other) tools in the system have 0 borrowings. ==

========================================
Press any key to return to previous menu...
```
Screenshot 37: Test Case Three Display Top Three

```
Please make a selection (1-5, or 0 to return to main menu): 5

Welcome to the Tool Library
==============Top Three Tools==============

== There are currently no existing tools in the system. ==

========================================
Press any key to return to previous menu...
```
Screenshot 38: Test Case Four Display Top Three

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