



# CSA 1017

## Data Structures and Algorithms 1

### Assignment

Mark Said Camilleri  
0306697M

B.Sc. (Hons) (Computing Science)  
University of Malta

Tuesday 24<sup>th</sup> May 2016

# Contents

	Page
<b>Plagiarism Declaration Form</b>	<b>2</b>
<b>Turnitin Originality Report</b>	<b>3</b>
<b>Statement of Completion</b>	<b>4</b>
<b>1 Arabic to Roman Numeral Converter</b>	<b>5</b>
1.1 The source code for Task 1 . . . . .	6
<b>2 Reverse Polish Notation Evaluator</b>	<b>8</b>
2.1 The source code for Task 2 . . . . .	9
2.1.1 Stack Class . . . . .	9
2.1.2 Question 2 Main Class . . . . .	11
<b>3 Prime Numbers</b>	<b>14</b>
3.1 Prime Number Checker using divisibility check . . . . .	14
3.1.1 The source code for 3.1 . . . . .	15
3.2 Prime Number Checker using The Sieve of Eratosthenes . . . . .	17
3.2.1 The source code for 3.2 . . . . .	18
<b>4 Shell Sort</b>	<b>21</b>
4.1 The source code for Task 4 . . . . .	22
<b>5 Approximation of a Square Root</b>	<b>25</b>
5.1 The source code for Task 5 . . . . .	26
<b>6 Matrix Multiplication</b>	<b>28</b>
6.1 The source code for Task 6 . . . . .	29
<b>7 Maximum Number in an Array</b>	<b>32</b>
7.1 The source code for Task 7 . . . . .	35
<b>8 Sine or Cosine Approximation</b>	<b>37</b>
8.1 The source code for Task 8 . . . . .	38
<b>9 Sum of Fibonacci Sequence</b>	<b>42</b>
9.1 The source code for Task 9 . . . . .	43

## FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

### Declaration

Plagiarism is defined as “the unacknowledged use, as one’s own, of work of another person, whether or not such work has been published, and as may be further elaborated in Faculty or University guidelines” (University Assessment Regulations, 2009, Regulation 39 (b)(i), University of Malta).

I / ~~We~~\*, the undersigned, declare that the [assignment / Assigned Practical Task report / Final Year Project report] submitted is my / our\* work, except where acknowledged and referenced.

I / ~~We~~\* understand that the penalties for committing a breach of the regulations include loss of marks; cancellation of examination results; enforced suspension of studies; or expulsion from the degree programme.

Work submitted without this signed declaration will not be corrected, and will be given zero marks.

\* Delete as appropriate.

(N. B. If the assignment is meant to be submitted anonymously, please sign this form and submit it to the Departmental Officer separately from the assignment).

Mark Said Camilleri

\_\_\_\_\_  
Student Name

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Student Name

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Student Name

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Student Name

\_\_\_\_\_  
Signature

CSA 1017

\_\_\_\_\_  
Course Code

Data Structures and Algorithms 1 - Assignment

\_\_\_\_\_  
Title of work submitted

24<sup>th</sup> May 2016

\_\_\_\_\_  
Date

*This page has been intentionally left blank for the inclusion of  
the Turnitin Originality Report*

# Statement of Completion

The questions below were the ones that have been attempted:

**Question 1** This question has been successfully completed.

**Question 2** This question has been successfully completed.

**Question 3** This question has been successfully completed.

**Question 4** This question has been successfully completed.

**Question 5** This question has been successfully completed.

**Question 6** This question has been successfully completed.

**Question 7** This question has been successfully completed.

**Question 8** This question has been successfully completed.

**Question 9** This question has been successfully completed.

---

Signature

---

Tuesday 24<sup>th</sup> May 2016

Date

# Task 1

## Arabic to Roman Numeral Converter

Input	Expected Output	Actual Output
1	I	I
2	II	II
4	IV	IV
5	V	V
6	VI	VI
9	IX	IX
10	X	X
20	XX	XX
40	XL	XL
49	XLIX	XLIX
50	L	L
60	LX	LX
90	XC	XC
99	XCIX	XCIX
100	C	C
150	CL	CL
400	CD	CD
499	CDXCIX	CDXCIX
500	D	D
600	DC	DC
900	CM	CM
999	CMXCIX	CMXCIX
1000	M	M
1024	MXXIV	MXXIV
2000	The input was not a valid number between 1 and 1024 Please try again and enter a number to convert:	The input was not a valid number between 1 and 1024 Please try again and enter a number to convert:
abc	The input was not a valid number between 1 and 1024 Please try again and enter a number to convert:	The input was not a valid number between 1 and 1024 Please try again and enter a number to convert:

## 1.1 The source code for Task 1

```
1  /**
2   * @author Mark Said Camilleri
3   * @version 20160509
4   */
5
6
7  import java.util.InputMismatchException;
8  import java.util.Scanner;
9
10
11 public class Question1 {
12
13     public static void main(String args[]) {
14
15         //Initialize Scanner object
16         Scanner in = new Scanner(System.in);
17         in.useDelimiter("\n");
18
19         /*===== WELCOME MESSAGE TO USER
20         =====*/
21         System.out.println("
22         -----");
23         System.out.println("|      CSA 1017 - Data Structures and
24 Algorithms 1      |");
25         System.out.println("
26         |-----|");
27         System.out.println("|      Submission by Mark Said Camilleri
28         |");
29         System.out.println("|      Task 1: Arabic to Roman Numeral
30 Converter      |");
31         System.out.println("
32         |-----|");
33         System.out.print("| Please enter a number between 1 and 1024: ")
34 ;
35
36         int toConvert = 0; //value to be converted.
37         boolean isError; // temporary boolean value used for error
38         checking of the input.
39         do {
40             isError = false;
41             try {
42                 toConvert = in.nextInt();
43             } catch (InputMismatchException e) {
44                 isError = true;
45                 in.next(); //To clear the buffer
46             }
47             /*===== Makes sure input is a number is between 1 and
48 1024 =====*/
49             if (isError || toConvert < 1 || toConvert > 1024) {
50                 /*===== OUTPUT ERROR MESSAGE TO THE USER
51                 =====*/
52                 System.out.println("
53                 |-----|");
54                 System.out.println("|The input was not a valid number
```

```
        between 1 and 1024|");
44         System.out.print("|Please try again and enter a number
to convert: ");
45     }
46     } while (isError || toConvert < 1 || toConvert > 1024);
47
48     System.out.printf("| %4d = %-24s in Roman Numerals |\n",
toConvert, convert(toConvert));
49
50 }
51
52 /**
53  * Takes an int decimal value and outputs a string of the same
54  * value in Roman Numerals.
55  *
56  * @param toConvert the decimal value to be converted to Roman
Numerals
57  * @return The roman numeral equivalent of the input parameter
58  */
59 private static String convert(int toConvert) {
60
61     //Defining the decimal and roman counterparts
62     final int dec[] = {1, 4, 5, 9, 10, 40, 50, 90, 100, 400, 500,
900, 1000};
63     final String rom[] = {"I", "IV", "V", "IX", "X", "XL", "L", "XC"
, "C", "CD", "D", "CM", "M"};
64
65     /* Begins by checking the input parameter against the
66     * largest roman numeral/numeral pair and works its way down
67     * to the unit numeral.
68     */
69     for (int i = dec.length - 1; i >= 0; i--) {
70         /* If the value is larger, then the output is concatenated
71         * with the output of the difference.
72         */
73         if (toConvert >= dec[i])
74             return rom[i] + convert(toConvert - dec[i]);
75     }
76     return ""; //What to return at 0, the base case.
77 }
78 }
```



## Task 2

# Reverse Polish Notation Evaluator

n is for unix toprule Input	Expected Output	Actual Output
4 5 +	9.0	9.0
12 6 -	6.0	6.0
3 2 /	1.5	1.5
7 2 *	14.0	14.0
23 85 + 92 *	9936.0	9936.0
43.5 3.2 - 4.5 * 3.24 +	184.59	184.59
34.8 62.11 * -76 /	-28.43984211	-28.439842105263157
282 -56 * 1024 - -55.6 *	934969.6	934969.6
Test	Your expression contained invalid characters. For input string "T" Your expression is invalid. Evaluation failed	Your expression contained invalid characters. For input string "T" Your expression is invalid. Evaluation failed
1 +	Stack is Empty. Your expression is invalid. Evaluation failed.	Stack is Empty. Your expression is invalid. Evaluation failed.
3 64 6 +	The stack has not been emptied. There are too many operands in your expression. Your expression is invalid. Evaluation failed.	The stack has not been emptied. There are too many operands in your expression. Your expression is invalid. Evaluation failed.
4 0 /	Infinity	Infinity

## 2.1 The source code for Task 2

### 2.1.1 Stack Class

```
1 import java.util.ArrayList;
2 import java.util.Collection;
3 import java.util.EmptyStackException;
4
5 /**
6  * @author Mark Said Camilleri
7  * @version 20160509
8  * A stack implemented as an ArrayList to have it dynamically increase
9  * its size.
10 */
11 public class Stack<E> extends ArrayList {
12
13     /**
14      * Default constructor. Calls the ArrayList default constructor
15      */
16     public Stack() {
17         super();
18     }
19
20     /**
21      * Initialised a stack with the contents of the Collection in the
22      * parameter.
23      *
24      * @param c the contents to initialise the stack with.
25      */
26     public Stack(Collection<? extends E> c) {
27         super(c);
28     }
29
30     /**
31      * Pushes the data onto the stack
32      *
33      * @param data data to be pushed on the stack
34      * @throws IndexOutOfBoundsException if not sucessfully pushed
35      */
36     public void push(E data) throws IndexOutOfBoundsException {
37         int prevSize = this.size();
38         this.add(data);
39
40         //Condition to check if the data has been successfully added.
41         if (!(this.size() == prevSize + 1))
42             throw new IndexOutOfBoundsException("Failed to push to stack
43 ");
44     }
45
46     /**
47      * Pops the topmost item from the stack.
48      * @return the data from the top of the stack is not empty.
49      * @throws EmptyStackException if the stack is empty.
50      */
51     public E pop() throws ArrayIndexOutOfBoundsException {
52         if (this.size() == 0) throw new EmptyStackException();
53     }
54 }
```

```
50         else return (E) this.remove(this.size() - 1);
51     }
52
53     /**
54     * Returns the data at the top of the stack without popping it.
55     * @return the data if the stack is not empty. null if it is empty.
56     */
57     public E peek() {
58         if (this.size() == 0) return null;
59         else return (E) this.get(this.size() - 1);
60     }
61
62     /**
63     * Returns a string representation of the contents of the stack.
64     * @overrides toString() in class AbstractCollection<E>
65     * @return The string representation of the ArrayList if not empty.
66     "Stack is empty" if it is empty.
67     */
68     public String toString() {
69         if (this.size() == 0) return "Stack is empty";
70         else return super.toString();
71     }
```

## 2.1.2 Question 2 Main Class

```

1 import java.util.EmptyStackException;
2 import java.util.Scanner;
3
4 /**
5  * @author Mark Said Camilleri
6  * @version 20160509
7  */
8 public class Question2 {
9     public static void main(String args[]) {
10
11         //Initialize Scanner object
12         Scanner in = new Scanner(System.in).useDelimiter("\n");
13
14         /*===== WELCOME MESSAGE TO USER
15         =====*/
16         System.out.println("
17         -----");
18         System.out.println("|      CSA 1017 - Data Structures and
19 Algorithms 1      |");
20         System.out.println("
21         |-----|");
22         System.out.println("|      Submission by Mark Said Camilleri
23         |");
24         System.out.println("|      Task 2: Reverse Polish Notation
25 evaluator      |");
26         System.out.println("
27         |-----|");
28         System.out.println("|      Note: This program can only do +,-,*
29 and /      |");
30         System.out.print("| Please enter an expression to evaluate: ");
31         //prompt for user input. Assumes it is rpnp.
32
33         /* Initialized a stack object (using the stack defined here).
34         * Note, no importing of the Stack class.
35         */
36         Stack<Double> nums = new Stack<>();
37
38         //Reads user input. Must be a valid RPN expression.
39         String expression = in.next();
40         System.out.println("
41         |-----|");
42         System.out.println("| Contents of the stack at each step:
43         |"); //some message to user.
44
45         boolean exceptionRaised = false; //used for error checking.
46         try {
47             //Iterates through the string inputted by the user.
48             for (int i = 0; i < expression.length(); i++) {
49                 char cChar = expression.charAt(i);
50
51                 /* If the current character is a space,
52                 * nothing needs to be done.
53                 */
54                 if (Character.isWhitespace(cChar)) continue;
55
56                 /* If it's a '+', then 2 numbers are popped, added and

```

```

46         * the answer is pushed onto the stack.
47     */
48     else if (cChar == '+') {
49         double num1 = nums.pop();
50         double num2 = nums.pop();
51
52         nums.push(num2 + num1);
53     }
54     /* If it's a '-', then 2 numbers are popped,
55     * subtracted and the answer is pushed onto the stack.
56     * The conjunction is to make sure that it's not
57     * detecting a negative number. The disjunction is
58     * true if the '-' is at the end of the string or
59     * there is a space after it. These both make sure
60     * that the '-' does not belong to a negative number
61     */
62     else if (cChar == '-' && (i == expression.length() - 1
|| Character.isWhitespace(expression.charAt(i + 1)))) {
63         double num1 = nums.pop();
64         double num2 = nums.pop();
65
66         nums.push(num2 - num1);
67     }
68     /* If it's a '*', then 2 numbers are popped,
69     * multiplied and the answer is pushed onto the stack.
70     */
71     else if (cChar == '*') {
72         double num1 = nums.pop();
73         double num2 = nums.pop();
74
75         nums.push(num2 * num1);
76     }
77     /* If it's a '/', then 2 numbers are popped,
78     * divided and the answer is pushed onto the stack.
79     */
80     else if (cChar == '/') {
81         double num1 = nums.pop();
82         double num2 = nums.pop();
83
84         nums.push(num2 / num1);
85     }
86     /*
87     * Otherwise, assuming it's inputted correctly, the
88     * character must be a number. In which case it is
89     * converted to a double (allowing for any real number
90     * to be inputted) and pushed onto the stack.
91     */
92     else {
93         int start = i++;
94         while (Character.isDigit(expression.charAt(i)) ||
expression.charAt(i) == '.')
95             i++;
96
97         nums.push(Double.parseDouble(expression.substring(
start, i)));
98     }
99     System.out.printf("| %-49s |\n", nums.toString());
100 }

```

```
101         if (nums.size() != 1) {
102             System.out.println("| The stack has not been emptied.
There are too |");
103             System.out.println("| many operands in your expression.
|");
104             exceptionRaised = true;
105         }
106
107     } catch (IndexOutOfBoundsException ioobe) {
108         System.out.printf("| %-49s |\n", ioobe.getMessage());
109         exceptionRaised = true;
110     } catch (EmptyStackException ese) {
111         System.out.println("| Stack is Empty.
|");
112         exceptionRaised = true;
113     } catch (NumberFormatException nfe) {
114         System.out.println("| Your expression contained invalid
characters. |");
115         System.out.printf("| %-49s |\n", nfe.getMessage());
116         exceptionRaised = true;
117     } finally {
118         if (exceptionRaised) {
119             System.out.println("| Your expression is invalid.
Evaluation failed. |");
120             System.out.println("-----
-----");
121             System.exit(1);
122         }
123     }
124     /*When the above iteration is complete, there should only be
125     * one item on the stack which is the answer.
126     */
127     System.out.println("
|-----|");
128     System.out.printf("| Answer of Evaluation = %-26s |\n", nums.pop
().toString());
129     System.out.println("-----
-----");
130 }
131 }
```

# Task 3

## Prime Numbers

### 3.1 Prime Number Checker using divisibility check

Input	Expected Output	Actual Output
1	1 is not a prime number	1 is not a prime number
2	2 is a prime number	2 is a prime number
3	3 is a prime number	3 is a prime number
4	4 is not a prime number	4 is not a prime number
-2	-2 is not a prime number	-2 is not a prime number
677	677 is a prime number	677 is a prime number
34939	34939 is a prime number	34939 is a prime number
188737204	188737204 is not a prime number	188737204 is not a prime number
381165334	381165334 is not a prime number	381165334 is not a prime number
947396057	947396057 is a prime number	947396057 is a prime number
9223372036854775807	9223372036854775807 is not a prime number	9223372036854775807 is not a prime number
-9223372036854775808	-9223372036854775808 is not a prime number	-9223372036854775808 is not a prime number
9223372036854775808	Your input was not accepted. Please restart the program and try again with a valid input.	Your input was not accepted. Please restart the program and try again with a valid input.
Test	Your input was not accepted. Please restart the program and try again with a valid input.	Your input was not accepted. Please restart the program and try again with a valid input.

### 3.1.1 The source code for 3.1

```

1 import java.util.InputMismatchException;
2 import java.util.Scanner;
3
4 /**
5  * @author Mark Said Camilleri
6  * @version 20160511
7  */
8
9 public class Question3a {
10
11     public static void main(String args[]) {
12
13         //Initialize Scanner object
14         Scanner in = new Scanner(System.in).useDelimiter("\n");
15
16         /*===== WELCOME MESSAGE TO USER
17         =====*/
18         System.out.println("
19         -----");
20         System.out.println("|      CSA 1017 - Data Structures and
21 Algorithms 1      |");
22         System.out.println("
23         |-----|");
24         System.out.println("|      Submission by Mark Said Camilleri
25         |");
26         System.out.println("|      Task 3.1: Prime Number Checker
27         |");
28         System.out.println("
29         |-----|");
30         System.out.print("| Please enter an integer to check: ");
31
32         try {
33             //The number to check whether or not it's prime
34             long prime = in.nextLong();
35
36             System.out.println("
37             |-----|");
38             if (isPrime(prime))
39                 System.out.printf("| %31d is a prime number |\n", prime)
40 ;
41             else
42                 System.out.printf("| %27d is not a prime number |\n",
43 prime);
44
45             System.out.println("-----
46             ");
47         } catch (InputMismatchException ime) {
48             System.out.println("| Your input was not accepted. Please
49 restart the      |");
50             System.out.println("| program and try again with a valid
51 input.          |");
52             System.out.println("-----
53             ");
54             System.exit(1);
55         }
56     }
57 }

```



```
43
44  /**
45   * This method checks the input parameter to see if it is a prime
46   * number or not.
47   *
48   * @param prime The number to check if it is prime
49   * @return true if the number is prime, false if it isn't
50   */
51  private static boolean isPrime(long prime) {
52      /*Firstly, if the number is 1, 0 or negative then it's not
53       * prime
54       */
55      if (prime <= 1) return false;
56      //If the number is 2, 2 is prime.
57      else if (prime == 2) return true;
58      //If the number is even and not 2, then it's not prime.
59      else if (prime % 2 == 0) return false;
60      /* Otherwise, divide this number by all odd numbers till the
61       * square root of the number. If one is divisible then it's
62       * not prime.
63       */
64      else {
65          double root = Math.sqrt(prime);
66          for (int i = 3; i <= root; i += 2) {
67              if (prime % i == 0) return false;
68          }
69          return true;
70      }
71  }
72 }
```

## 3.2 Prime Number Checker using The Sieve of Eratosthenes

For this an `int` variable had to be used, due to it being the length of an array. As a result the range of numbers that can be checked was smaller.

Input	Expected Output	Actual Output
1	1 is not a prime number	1 is not a prime number
2	2 is a prime number	2 is a prime number
3	3 is a prime number	3 is a prime number
4	4 is not a prime number	4 is not a prime number
-2	Sieve of Eratosthenes only works on +ve integers. Please restart the program and try again with a valid input	Sieve of Eratosthenes only works on +ve integers. Please restart the program and try again with a valid input
677	677 is a prime number	677 is a prime number
34939	34939 is a prime number	34939 is a prime number
188737204	188737204 is not a prime number	188737204 is not a prime number
381165334	381165334 is not a prime number	381165334 is not a prime number
947396057	947396057 is a prime number	947396057 is a prime number
2147483646	2147483646 is not a prime number	Requested array size exceeds VM limit Please restart the program and try again with a smaller input <sup>1</sup>
-2147483646	Sieve of Eratosthenes only works on +ve integers. Please restart the program and try again with a valid input	Sieve of Eratosthenes only works on +ve integers. Please restart the program and try again with a valid input
9223372036854775807	Your input was not accepted. Please restart the program and try again with a valid input.	Your input was not accepted. Please restart the program and try again with a valid input.
Test	Your input was not accepted. Please restart the program and try again with a valid input.	Your input was not accepted. Please restart the program and try again with a valid input.

<sup>1</sup>This error depends on the amount of memory allocated for the program

### 3.2.1 The source code for 3.2

```

1 import java.util.Arrays;
2 import java.util.InputMismatchException;
3 import java.util.Scanner;
4
5 /**
6  * @author Mark Said Camilleri
7  * @version 20160511
8  */
9 public class Question3b {
10
11     public static void main(String args[]) {
12
13         //Initialize Scanner object
14         Scanner in = new Scanner(System.in).useDelimiter("\n");
15
16         /*===== WELCOME MESSAGE TO USER
17         =====*/
18         System.out.println("
19         -----");
20         System.out.println("|      CSA 1017 - Data Structures and
21 Algorithms 1      |");
22         System.out.println("
23         |-----|");
24         System.out.println("|      Submission by Mark Said Camilleri
25         |");
26         System.out.println("|      Task 3.2: Sieve of Eratosthenes
27         |");
28         System.out.println("
29         |-----|");
30         System.out.print("| Please enter a positive integer to check: ")
31 ;
32         try {
33             /*
34              * Value to check if it's prime. Note that this is now an int
35              * since the Sieve of Eratosthenes requires an array of this
36              * amount of elements.
37              */
38             int prime = in.nextInt();
39
40             System.out.println("
41             |-----|");
42             if (sieve(prime))
43                 System.out.printf("| %31d is a prime number |\n", prime)
44 ;
45             else
46                 System.out.printf("| %27d is not a prime number |\n",
47 prime);
48             System.out.println("-----
49             ");
50         } catch (InputMismatchException ime) {
51             System.out.println("| Your input was not accepted. Please
52 restart the      |");
53             System.out.println("| program and try again with a valid
54 input.          |");
55             System.out.println("-----
56             ");
57         }
58     }
59 }

```

```

42         System.exit(1);
43     } catch (IllegalArgumentException iae) {
44         System.out.printf("| %-49s |\n", iae.getMessage());
45         System.out.println("| Please restart the program and try
again with a    |");
46         System.out.println("| valid input.
|");
47         System.out.println("-----
");
48         System.exit(1);
49     } catch (OutOfMemoryError oome) {
50         System.out.printf("| %-49s |\n", oome.getMessage());
51         System.out.println("| Please restart the program and try
again with a    |");
52         System.out.println("| smaller input.
|");
53         System.out.println("-----
");
54         System.exit(1);
55     }
56 }
57
58 /**
59  * Runs the Sieve of Eratosthenes algorithm to check if the input
60  * is a prime number or not.
61  *
62  * @param prime The number to check if it is prime or not.
63  * @return true if the input is prime, false if it isn't.
64  * @throws IllegalArgumentException if the input is <= 0
65  */
66 private static boolean sieve(int prime) throws
IllegalArgumentException, OutOfMemoryError {
67     //Checks whether the input is valid or not
68     if (prime <= 0)
69         //Throws exception if input is not valid.
70         throw new IllegalArgumentException("Sieve of Eratosthenes
only works on +ve integers.");
71     else {
72         //Each ith element is true if i-1 is prime. False otherwise.
73         boolean[] nos = new boolean[prime];
74
75         //We begin by assuming all the values are prime.
76         Arrays.fill(nos, true);
77
78         //Then, 1 is crossed out since it is a square.
79         nos[0] = false;
80
81         /*
82          * After which each value is checked. i is assumed to be prime
83          * unless marked as not prime. Multiples of i are not prime.
84          * Therefore all the multiples of i are marked as not prime.
85          * This keeps going on until the inputted value is set to not
86          * prime or reached and still set to prime.
87          */
88         for (int i = 2; i <= prime; i++) {
89             //Checks if i is marked as prime.
90             if (nos[i - 1]) {

```

```
91         //If it is, all multiples of i are marked as not
prime
92         for (int j = i + i; j <= prime; j += i) {
93             nos[j - 1] = false;
94         }
95     }
96     /*
97     * If the inputted value is marked as prime, we can stop
98     * there since we found out whether it's prime or not.
99     * Otherwise, this program keeps going on till the end
100    * (i = prime).
101    */
102    if (!nos[prime - 1]) break;
103 }
104
105 return nos[prime - 1];
106 }
107 }
108 }
```

# Task 4

## Shell Sort

Since the requirement of this task was for the program to generate an array containing 16,384 elements, all of which are random numbers, and sort them, it is impossible to write the contents of the array for a reliable amount of tests and keep this document to a reasonable size. As a result, the program itself checks whether the array that has been sorted, is in fact sorted. This is done using the algorithm `checkSortedAscending` as given in Algorithm 1 (also included in the source code).

```
1 Algorithm: Check if sorted in ascending order
   Input: int array
   Output: boolean
2 for  $i = 0 \dots \text{length of array} - 1$  do
3   | if element at  $i$  > element at  $i+1$  then
4   | | return false
5   | end if
6 end for
7 return true
```

**Algorithm 1:** `checkSortedAscending(int[] array)`

## 4.1 The source code for Task 4

```

1 import java.util.Arrays;
2
3 /**
4  * @author Mark Said Camilleri
5  * @version 20160516
6  */
7 public class Question4 {
8
9     public static final int SIZE = 16384;
10
11     public static void main(String[] args) {
12
13         /*===== WELCOME MESSAGE TO USER
14         =====*/
15         System.out.println("
16         -----");
17         System.out.println("|      CSA 1017 - Data Structures and
18         Algorithms 1      |");
19         System.out.println("
20         |-----|");
21         System.out.println("|      Submission by Mark Said Camilleri
22         |");
23         System.out.println("|      Task 4: Shell Sorting Algorithm
24         |");
25         System.out.println("
26         |-----|");
27         System.out.println("| The array to be sorted is:
28         |");
29
30         //The array, which will eventually be sort
31         int[] arr = new int[SIZE];
32
33         //Populating the array with random data.
34         for (int i = 0; i < arr.length; i++) {
35             arr[i] = (int) (Math.random() * SIZE);
36         }
37
38         //Displays the unsorted array to the user.
39         System.out.println("Unsorted Array: " + Arrays.toString(arr));
40
41         //Sorts the array
42         int[] sorted = shellSort(arr);
43
44         //Displays the sorted array to the user
45         System.out.println("Sorted Array:  " + Arrays.toString(sorted))
46         ;
47
48         //Displays whether the array is indeed sorted or not.
49         System.out.println("Array is sorted: " + checkSortedAscending(
50         sorted));
51     }
52
53     /**
54     * Sorts the inputted array using the shell sort algorithm.
55     */

```

```

46     * @param unsorted The array to be sorted
47     * @return The sorted version of the array
48     */
49     private static int[] shellSort(int[] unsorted) {
50
51         /*
52          * First, the program begins by making a deep copy of the
53          * array to make sure the original one isn't affected.
54          */
55         int[] sorted = Arrays.copyOf(unsorted, SIZE);
56
57         /*
58          * This loop begins with the iterator being set at half the
59          * size of the array, - 1. This then iterates downwards by
60          * incrementing the iterator, dividing it by 2 and subtracting
61          * 1 from it, until it performs its final iteration at a
62          * value of 1.
63          */
64         for (int sep = (unsorted.length / 2) - 1; sep > 0; sep = (sep +
1) / 2 - 1) {
65             /*
66              * This for loop goes through the items between sep and
67              * the end of the array. To then use an bu sort
68              * algorithm to switch it
69              */
70             for (int i = sep; i < SIZE; i++) {
71                 /*
72                  * The algorithm begins by storing the value in a
73                  * temporary variable.
74                  */
75                 int temp = sorted[i];
76
77                 //iterator for next for loop. Used also outside loop.
78                 int j;
79                 /*
80                  * Finds good position of temp in steps of sep, sort
81                  * of like insertion sort.
82                  */
83                 for (j = i; j >= sep && sorted[j - sep] > temp; j -= sep
) {
84                     /*
85                      * Moves the (j-sep)th by a step of sep to
86                      * leave space for temp at its proper place.
87                      */
88                     sorted[j] = sorted[j - sep];
89                 }
90                 //Once found temp is stored in its proper place.
91                 sorted[j] = temp;
92             }
93         }
94         return sorted;
95     }
96 }
97
98 /**
99  * Method that checks whether the elements in the array in the
100  * parameter are all in ascending order.
101  */

```



```
102     * @param array The array to be checked.
103     * @return true if all elements are in ascending order, false
otherwise.
104     */
105     public static boolean checkSortedAscending(int[] array) {
106
107         /* Iterates through all elements except for the last one.
108         * If an unsorted element is found for loop stops.
109         */
110         for (int i = 0; i < array.length - 1; i++) {
111             /*
112             * If the ith element is larger than the i-1th element
113             * then the array is not sorted. Method ends returning
114             * false
115             */
116             if (array[i] > array[i + 1])
117                 return false;
118         }
119         /* If the condition is never satisfied, then the method returns
120         * true.
121         */
122         return true;
123     }
124 }
```

# Task 5

## Approximation of a Square Root

For this task, the Newton-Raphson algorithm was used, with the formula shown in Equation 5.2, which is basically a specific case of the general formula for the Newton-Raphson algorithm which is given in Equation 5.1.

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} \quad (5.1)$$

$$x_{n+1} = x_n - \frac{x_n^2 - \text{input}}{2x_n} \quad (5.2)$$

	Input	Expected Output	Actual Output
	1	1	1
	2	1.414213562	1.414213562373095
	4	2	2
	100	10	10
	1000	31.6227766	31.622776601683793
	9999	99.99499987	99.99499987499375
	29535083406040468068234	$1.718577418 \times 10^{11}$	$1.7185774176929147 \times 10^{11}$
	45.3	6.730527468	6.730527468185536
	5.6	2.366431913	2.3664319132398464
	0.25	0.5	0.5
	0.125	0.3535533906	0.35355339059327373
	-4	Your input was not accepted since it was $\leq 0$ Please enter a POSITIVE number to find its square root:	Your input was not accepted since it was $\leq 0$ Please enter a POSITIVE number to find its square root:
	0	Your input was not accepted since it was $\leq 0$ Please enter a POSITIVE number to find its square root:	Your input was not accepted since it was $\leq 0$ Please enter a POSITIVE number to find its square root:
	Test	Your input was not accepted. Please try again:	Your input was not accepted. Please try again:

## 5.1 The source code for Task 5

```
1 import java.util.InputMismatchException;
2 import java.util.Scanner;
3
4 /**
5  * @author Mark Said Camilleri
6  * @version 20160516
7  */
8 public class Question5 {
9     public static void main(String[] args) {
10
11         /*===== WELCOME USER
12         =====*/
13         System.out.println("
14         -----");
15         System.out.println("|      CSA 1017 - Data Structures and
16         Algorithms 1      |");
17         System.out.println("
18         |-----|");
19         System.out.println("|      Submission by Mark Said Camilleri
20         |");
21         System.out.println("|      Task 5: Approximation of a Square
22         Root      |");
23         System.out.println("
24         |-----|");
25         System.out.print("| Please enter a positive number to find its
26         square root: ");
27
28         //variable to state whether input should be accepted or not.
29         boolean isWrong = false;
30
31         //input variable. This shall be x1 and the first value of xn,
32         double input = 1;
33         do {
34             try {
35                 //accepts user input.
36                 input = new Scanner(System.in).nextDouble();
37
38                 /*
39                  * If the value is not positive, then it will raise an
40                  * error
41                  */
42                 if (input <= 0) {
43                     isWrong = true;
44                     System.out.println("| Your input was not accepted
45                     since it was \u2264 0");
46                     System.out.print("| Please enter a POSITIVE number
47                     to find its square root: ");
48                 }
49
50                 //It will also raise an error if it's not a number.
51             } catch (InputMismatchException imme) {
52                 isWrong = true;
53                 System.out.print("| Your input was not accepted. Please
54                 try again: ");
55             }
56         }
```

```
45         //This is repeated until a correct value was inputted.
46     } while (isWrong);
47
48     //Setting the first value for x_n
49     double curr_x = Math.random() * input + 1;
50     //Initializing x_(n-1)
51     double prev_x;
52
53     //Counts the number of steps taken.
54     int steps = 0;
55
56     do {
57         steps++;
58         prev_x = curr_x;
59
60         //Newton-Raphson formula on y=sqrt(x)
61         curr_x = prev_x - (Math.pow(prev_x, 2) - input) / (2 *
prev_x);
62         /*
63          * This will keep on, either until there has been no change
64          * or until it has done Integer.MAX_VALUE number of steps.
65          */
66     }
67     while (curr_x != prev_x && curr_x != Double.NaN && steps <
Integer.MAX_VALUE);
68
69     System.out.println("
|-----|");
70
71     /*
72     * If the value is not the same as the sqrt computed by the
73     * built-in sqrt method, then it's approximately equal to,
74     * which is denoted by \u2248.
75     */
76     char sign = (curr_x == Math.sqrt(input)) ? '=' : '\u2248';
77
78     System.out.println("The square root of " + input + " " + sign +
" " + curr_x);
79     System.out.println("This was done in " + steps + " steps");
80 }
81 }
```

# Task 6

## Matrix Multiplication

The methods used in this programme were created to work for any  $n \times n$  matrices, with  $n$  being specified by a constant in the program called `SIZE`. Since writing the tests for  $32 \times 32$  matrices in this document would be too cumbersome,  $3 \times 3$  matrices shall be tested instead.

It is worth noting that the matrices used to test the output are the matrices outputted by the program. Since the program rounds each matrix (matrices **A**, **B** and **AB**) to 2 d.p. (and the expected output is also being rounded to 2 d.p) the expected output and the actual output will not be exactly the same, but they should be approximately equal to each other.

A	B	Expected AB	Actual AB
$\begin{bmatrix} 6.72 & 1.99 & 1.73 \\ 3.85 & 0.00 & 3.82 \\ 2.02 & 8.81 & -2.13 \end{bmatrix}$	$\begin{bmatrix} -1.92 & 2.21 & -2.42 \\ -0.18 & -5.64 & 0.03 \\ -0.70 & -3.86 & -6.60 \end{bmatrix}$	$\begin{bmatrix} -14.47 & -3.05 & -27.62 \\ -10.07 & -6.24 & -34.53 \\ -3.97 & -37.00 & 9.43 \end{bmatrix}$	$\begin{bmatrix} -14.48 & -3.01 & -27.66 \\ -10.07 & -6.24 & -34.60 \\ -3.96 & -36.99 & 9.43 \end{bmatrix}$
$\begin{bmatrix} 0.98 & 8.13 & -1.21 \\ 2.36 & -3.08 & -3.51 \\ 9.54 & -7.90 & -8.48 \end{bmatrix}$	$\begin{bmatrix} 3.67 & -0.20 & -7.32 \\ -4.25 & -7.69 & 9.94 \\ 8.91 & 3.91 & -0.75 \end{bmatrix}$	$\begin{bmatrix} -41.74 & -67.45 & 74.55 \\ -9.52 & 9.49 & -45.26 \\ -6.97 & 25.69 & -142.00 \end{bmatrix}$	$\begin{bmatrix} -41.75 & -67.48 & 74.53 \\ -9.47 & 9.52 & -45.27 \\ -6.97 & 25.64 & -141.96 \end{bmatrix}$
$\begin{bmatrix} -5.62 & 0.99 & 4.84 \\ 3.69 & 2.17 & 9.55 \\ -5.38 & -3.36 & -6.33 \end{bmatrix}$	$\begin{bmatrix} -6.78 & 6.98 & 3.41 \\ 8.55 & 3.79 & -1.39 \\ -8.44 & -1.03 & 4.98 \end{bmatrix}$	$\begin{bmatrix} 5.72 & -40.46 & 3.56 \\ 25.36 & 76.56 & 77.40 \\ 49.00 & 137.66 & 149.57 \end{bmatrix}$	$\begin{bmatrix} 5.79 & -40.48 & 3.51 \\ -87.04 & 24.11 & 57.07 \\ 61.22 & -43.76 & -45.17 \end{bmatrix}$
$\begin{bmatrix} -9.31 & 8.19 & 2.23 \\ -2.87 & 7.49 & 1.03 \\ 9.20 & -5.98 & 7.96 \end{bmatrix}$	$\begin{bmatrix} -1.38 & -4.24 & -7.42 \\ 0.23 & 1.28 & 9.99 \\ 8.33 & 5.48 & 6.01 \end{bmatrix}$	$\begin{bmatrix} 33.31 & 62.18 & 164.30 \\ 14.26 & 27.40 & 102.31 \\ 52.24 & -3.04 & -80.16 \end{bmatrix}$	$\begin{bmatrix} 33.29 & 62.25 & 164.22 \\ 14.25 & 27.42 & 102.29 \\ 52.21 & -3.09 & -80.15 \end{bmatrix}$
$\begin{bmatrix} -6.14 & 7.85 & 6.00 \\ -8.71 & 3.36 & -1.96 \\ -4.86 & 8.48 & 4.84 \end{bmatrix}$	$\begin{bmatrix} -0.47 & -2.13 & 3.90 \\ -4.35 & -5.06 & 6.65 \\ -3.94 & -2.29 & -8.39 \end{bmatrix}$	$\begin{bmatrix} -54.90 & -40.38 & -22.08 \\ -2.80 & 6.04 & 4.82 \\ -53.67 & -43.64 & -3.17 \end{bmatrix}$	$\begin{bmatrix} -54.91 & -40.38 & -22.12 \\ -2.77 & 6.07 & 4.74 \\ -53.71 & -43.67 & -3.19 \end{bmatrix}$
$\begin{bmatrix} -4.13 & 4.79 & -8.23 \\ -6.02 & 0.78 & -1.33 \\ -5.98 & -2.59 & 5.39 \end{bmatrix}$	$\begin{bmatrix} 6.72 & 5.18 & 0.65 \\ 7.19 & 6.84 & 2.82 \\ 6.72 & 8.95 & -2.87 \end{bmatrix}$	$\begin{bmatrix} -48.62 & -62.29 & 34.44 \\ -43.78 & -37.75 & 2.10 \\ -22.59 & -0.45 & -26.66 \end{bmatrix}$	$\begin{bmatrix} -48.66 & -62.29 & 34.42 \\ -43.76 & -37.74 & 2.07 \\ -22.59 & -0.51 & -26.67 \end{bmatrix}$

## 6.1 The source code for Task 6

```

1  /**
2   * @author Mark Said Camilleri
3   * @version 20160517
4   */
5  public class Question6 {
6
7      /**
8       * Stores the size of the matrices
9       */
10     public static final int SIZE = 32;
11
12     public static void main(String[] args) {
13
14         /*===== WELCOME USER
15         =====*/
16         System.out.println("
17         -----");
18         System.out.println("|      CSA 1017 - Data Structures and
19         Algorithms 1      |");
20         System.out.println("
21         |-----|");
22         System.out.println("|      Submission by Mark Said Camilleri
23         |");
24         System.out.println("|      Task 6: Matrix Multiplication
25         |");
26         System.out.println("
27         |-----|");
28
29         /*
30          * The 2 matrices. Matrix A will be multiplied with matrix B
31          * to form matrix AB.
32          */
33         double[][] matrixA = new double[SIZE][SIZE];
34         double[][] matrixB = new double[SIZE][SIZE];
35
36         //Put random values from 1 to 10 in matrixA
37         for (int i = 0; i < SIZE; i++) {
38             for (int j = 0; j < SIZE; j++) {
39                 matrixA[i][j] = Math.random() * 20 - 10;
40             }
41         }
42
43         //Put random values from 1 to 10 in matrixB
44         for (int i = 0; i < SIZE; i++) {
45             for (int j = 0; j < SIZE; j++) {
46                 matrixB[i][j] = Math.random() * 20 - 10;
47             }
48         }
49
50         //Multiplied matrix
51         double[][] result = new double[SIZE][SIZE];
52
53         /*
54          * Transposes MatrixB. This is done to make the multiplication

```

```

49     * easier since the method would accept 2 arrays, one for the
50     * row and the other for the column.
51     */
52     double [][] matBtranspose = matTranspose(matrixB);
53
54     /*
55     * Multiplies each row of Matrix A with each column of Matrix B
56     * and adds them up to get the value of each cell.
57     */
58
59     for (int i = 0; i < SIZE; i++) {
60         for (int j = 0; j < SIZE; j++) {
61             result[i][j] = cellMult(matrixA[i], matBtranspose[j]);
62         }
63     }
64     //Outputs Matrix A
65     System.out.print("Matrix A = ");
66     displayMatrix(matrixA);
67
68
69     System.out.println();
70     System.out.print("Matrix B = ");
71     displayMatrix(matrixB);
72
73     System.out.println();
74     System.out.print("  A * B =  ");
75     displayMatrix(result);
76
77 }
78
79 /**
80  * Performs a matrix multiplication for 1 cell only.
81  *
82  * @param row The row of the first matrix to be multiplied
83  * @param col The column of the second matrix to be multiplied
84  * @return The value of the cell that resides in both the row and
85  * column that were inputted, for the resultant matrix.
86  */
87 public static double cellMult(double[] row, double[] col) {
88     //Result to be returned when finished.
89     double result = 0;
90
91     for (int i = 0; i < SIZE; i++) {
92         result += (row[i] * col[i]);
93     }
94
95     return result;
96 }
97
98 /**
99  * Transposes a square matrix of n x n size
100  *
101  * @param matrix The matrix to be transposed
102  * @return matrix transposed
103  */
104 public static double [][] matTranspose(double [][] matrix) {
105     double [][] transposed = new double[matrix.length][matrix[0].

```

```
length];
106
107     for (int i = 0; i < transposed.length; i++) {
108         for (int j = 0; j < transposed[0].length; j++) {
109             transposed[i][j] = matrix[j][i];
110         }
111     }
112
113     return transposed;
114 }
115
116 /**
117  * Displays the matrix to the user.
118  *
119  * @param matrix The matrix to be displayed to the user.
120  */
121 public static void displayMatrix(double[][] matrix) {
122     for (int i = 0; i < matrix.length; i++) {
123
124         for (int j = 0; j < matrix[i].length; j++) {
125             System.out.printf("%7.2f ", matrix[i][j]);
126         }
127         System.out.println();
128
129         //Don't print this space after the last row
130         if (i < matrix.length - 1) {
131             System.out.print("          ");
132         }
133     }
134 }
135 }
```



## Task 7

### Maximum Number in an Array

#### Test 1

Input 1

Expected Output 1

Actual Output 1

#### Test 2

Input 1 1

Expected Output 1

Actual Output 1

#### Test 3

Input 1 2

Expected Output 2

Actual Output 2

#### Test 4

Input 2 1

Expected Output 2

Actual Output 2

#### Test 5

Input 1 2 1

Expected Output 2

Actual Output 2

**Test 6**

**Input** 1 1 1 1 1

**Expected Output** 1

**Actual Output** 1

**Test 7**

**Input** 1 2 3 4 5 6

**Expected Output** 6

**Actual Output** 6

**Test 8**

**Input** 2 0 -3 10 3

**Expected Output** 10

**Actual Output** 10

**Test 9**

**Input** -9 -10 -5 -2 5

**Expected Output** 5

**Actual Output** 5

**Test 10**

**Input** -70210333 620267078 832297266 -242136666 -759786803 89498046 390942259  
-616830953 707423547 190501876

**Expected Output** 832297266

**Actual Output** 832297266

**Test 11**

**Input** 680932039 798137906 1362068 -482386095 976166649 54797596 264771471  
906347353 -674021294 -491689938

**Expected Output** 976166649

**Actual Output** 976166649

**Test 12**

**Input** 463847872 970322047 994450928 475574164 639319683 -942622068 -319105910  
-453518765 -167026456 579529276

**Expected Output** 994450928

**Actual Output** 994450928

**Test 13**

**Input** 1 2 3 4 e

**Expected Output** There was an error processing your input. Please try again.

**Actual Output** There was an error processing your input. Please try again.

**Test 14**

**Input** Test

**Expected Output** There was an error processing your input. Please try again.

**Actual Output** There was an error processing your input. Please try again.

## 7.1 The source code for Task 7

```

1 import java.util.Arrays;
2 import java.util.Scanner;
3
4 /**
5  * @author Mark Said Camilleri
6  * @version 20160517
7  */
8 public class Question7 {
9     public static void main(String[] args) {
10
11         /*===== WELCOME USER
12         =====*/
13         System.out.println("
14         -----");
15         System.out.println("|      CSA 1017 - Data Structures and
16         Algorithms 1      |");
17         System.out.println("
18         |-----|");
19         System.out.println("|              Submission by Mark Said Camilleri
20         |");
21         System.out.println("|              Task 7: Largest Number
22         |");
23         System.out.println("
24         |-----|");
25
26         Scanner in = new Scanner(System.in);
27
28         //This will store the numbers before formatted as numbers.
29         String[] text_nos;
30         int[] numbers = {0};
31
32         /* This is to ask the user to input the numbers again if the
33         * user has provided us with a bad input.
34         */
35         boolean inputIsCorrect;
36         do {
37             try {
38                 inputIsCorrect = true;
39
40                 //Ask user for input.
41                 System.out.println("| Please enter a list of integers.
42                 Seperate them |");
43                 System.out.println("| with a space. Press Enter at the
44                 end of the list: |");
45
46                 //Reads input and splits it to string array.
47                 text_nos = in.nextLine().split("\\s");
48
49                 //Creates int array to store them.
50                 numbers = new int[text_nos.length];
51
52                 //Parses the strings in the string array to integers.
53                 for (int i = 0; i < text_nos.length; i++) {
54                     numbers[i] = Integer.parseInt(text_nos[i]);
55                 }
56

```

```

47         } catch (NumberFormatException nme) {
48
49             //Flags program to ask again for input.
50             inputIsCorrect = false;
51
52             //Tells user there was an error
53             System.out.println("
|-----|");
54             System.out.println("|       There was an error processing
your input.   |");
55             System.out.println("|                               Please try again.
|");
56             System.out.println("
|-----|");
57         }
58     } while (!inputIsCorrect);
59
60     System.out.println("
|=====|");
61     System.out.printf("| The maximum number from your list was: %10d
|\n", findMax(numbers, Integer.MIN_VALUE));
62     System.out.println("
|=====|");
63 }
64
65 /**
66  * Recursive function to find the maximum number in an array
67  *
68  * @param nums The array to return its max value
69  * @param max Current maximum value. This should start with
70  *            Integer.MIN_VALUE.
71  * @return the maximum value.
72  */
73 public static int findMax(int[] nums, int max) {
74
75     //Base case. If array is empty.
76     if (nums.length == 0) {
77         return max;
78     } else {
79
80         /* If the element at startIndex > max, then it is the
81          * current maximum value.
82          */
83         if (nums[0] > max) {
84             max = nums[0];
85         }
86
87         /* Recursive call. Checks this max with the array starting
88          * from the next element
89          */
90         return findMax(Arrays.copyOfRange(nums, 1, nums.length), max
91     );
92 }
93 }
94 }

```

# Task 8

## Sine or Cosine Approximation

*N.B.: All these tests have been carried out with an approximation of 100 terms*

Input		Output	
Program	Mathematical	Expected	Actual
s0.5pir	$\sin(\frac{\pi}{2} \text{ rad})$	1.000000	1.000000
s270d	$\sin(270^\circ)$	-1.000000	-1.000000
c0.25pir	$\cos(\frac{\pi}{4} \text{ rad})$	0.707107	0.707107
s45d	$\sin(45^\circ)$	0.707107	0.707107
s100pid	$\sin(100\pi^\circ)$	-0.717406	-0.717406
c1r	$\cos(1 \text{ rad})$	0.540302	0.540302
c2pir	$\cos(2\pi \text{ rad})$	1.000000	1.000000
s8348pir	$\sin(8348\pi \text{ rad})$	0.000000	0.000000
1r	1 rad	Please enter the input with the function character	Please enter the input with the function character
100	100	Please enter the input with the function character	Please enter the input with the function character
test	-	Please enter the input with the function character	Please enter the input with the function character
s180	$\sin(180)$	Please enter the input with the unit character	Please enter the input with the unit character
crest	-	Please enter the input with the unit character	Please enter the input with the unit character
sd	$\sin(^{\circ})$	Your input could not be read. Please start over and input the expression again	Your input could not be read. Please start over and input the expression again

## 8.1 The source code for Task 8

```

1 import java.util.InputMismatchException;
2 import java.util.Scanner;
3
4 /**
5  * @author Mark Said Camilleri
6  * @version 20160523
7  */
8 public class Question8 {
9     public static void main(String[] args) {
10         System.out.println("
11         -----");
12         System.out.println("|      CSA 1017 - Data Structures and
13         Algorithms 1      |");
14         System.out.println("
15         |-----|");
16         System.out.println("|      Submission by Mark Said Camilleri
17         |");
18         System.out.println("|      Task 8: Sine or Cosine
19         Approximation      |");
20         System.out.println("
21         |-----|");
22
23         /*===== ASK USER FOR EXPRESSION INPUT
24         =====*/
25         System.out.println("| Please enter \'s\' or \'c\' to compute the
26         sine or      |");
27         System.out.println("| cosine function respectively, followed by
28         the          |");
29         System.out.println("| value to compute it on. Use \"pi\" for pi.
30         This         |");
31         System.out.println("| should be followed by \'r\' or \'d\' for
32         radians or   |");
33         System.out.println("| or degrees respectively.
34         |");
35         System.out.println("
36         |-----|");
37         System.out.println("| For example, sin(2pi radians) is entered
38         as s2pir |");
39         System.out.println("|      or cos(180 degrees) is entered as
40         c180d      |");
41         System.out.println("
42         |-----|");
43
44         /*===== ACCEPT EXPRESSION INPUT
45         =====*/
46         Scanner in = new Scanner(System.in).useDelimiter("\n");
47
48         String exp = ""; //Default expression is empty string.
49
50         /*===== CHECK IF INPUT IS CORRECT
51         =====*/
52         boolean isWrong; //Used to ask user to input again
53         do {
54             isWrong = false; //Assumes input will be correct.
55             exp = in.nextLine(); //Takes user input

```

```

38
39 //Incorrect input if first character is not c or s (function
40 )
41     if (exp.charAt(0) != 's' && exp.charAt(0) != 'c') {
42         isWrong = true;
43         System.out.println("| Please enter the input with the
function character|");
44         //Incorrect input if last character is not d or r (unit)
45     } else if (exp.charAt(exp.length() - 1) != 'd' && exp.charAt
(exp.length() - 1) != 'r') {
46         isWrong = true;
47         System.out.println("| Please enter the input with the
unit character |");
48     } else {
49         try {
50             /*===== PARSE USER INPUT
=====*/
51             /* First character determines which function to
52             * evaluate
53             */
54             char fn = exp.charAt(0);
55
56             //Last character determines the units
57             char units = exp.charAt(exp.length() - 1);
58
59             double angle; //Where angle is stored
60             //Multiplies the value by pi if "pi" is inputted.
61             if (exp.contains("pi")) {
62                 //If a number isn't present, then it's 1*PI
63                 //Throws a NumberFormatException
64                 angle = ((exp.length() == 4) ? 1 : Double.
valueOf(exp.substring(1, exp.length() - 3))) * Math.PI;
65             } else {
66                 //Throws a NumberFormatException
67                 angle = Double.valueOf(exp.substring(1, exp.
length() - 1));
68             }
69
70             /*
71             * Converts to radians since Maclaurin's expansion
72             * works for radians
73             */
74             if (units == 'd') angle = Math.toRadians(angle);
75
76             /* Reduces the angle to between -2pi and 2pi. This
77             * makes it easier to compute. Sine and Cos are
78             * periodic functions.
79             */
80             angle %= (2 * Math.PI);
81
82             /*===== ASK USER HOW MANY TERMS TO
EVALUATE =====*/
83             System.out.println("| Please enter the number of
terms to evaluate |");
84             System.out.println("| the approximation of the
expression inserted |");
85
86             //Number of terms to be evaluated for the series

```



```

86         int n = in.nextInt();
87
88         //Sine and Cosine are local methods
89         double result = (fn == 's') ? sine(angle, n) :
cosine(angle, n);
90
91         System.out.printf("| The answer is: %-34f |\n",
result);
92
93         /* Catches an Exception if the input is not in the
94          * correct form.
95          */
96         } catch (NumberFormatException | InputMismatchException
except) {
97             System.out.println("| Your input could not be read.
Please start over |");
98             System.out.println("|               and input the
expression again |");
99
100            in.nextLine();
101
102            isWrong = true;
103        }
104    }
105    } while (isWrong);
106 }
107
108 /**
109  * Approximates the sine using Maclaurin's series expansion
110  *
111  * @param angle Angle in radians to calculate sin for
112  * @param terms Number of terms to calculate
113  * @return An approximation to sin(angle)
114  */
115 public static double sine(double angle, int terms) {
116     double result = 0;
117     //Adds the nth term to result
118     for (int n = 0; n <= terms; n++) {
119         result += (Math.pow(-1, n) * Math.pow(angle, 2 * n + 1)) /
fact(2 * n + 1);
120     }
121     return result;
122 }
123
124 /**
125  * Approximates the cosine using Maclaurin's series expansion
126  * @param angle Angle in radians to calculate cos for
127  * @param terms Number of terms to calculate
128  * @return An approximation to cos(angle)
129  */
130 public static double cosine(double angle, int terms) {
131     double result = 0;
132     //Adds the nth term to result
133     for (int n = 0; n <= terms; n++) {
134         result += (Math.pow(-1, n) * Math.pow(angle, 2 * n)) / fact
(2 * n);
135     }
136     return result;

```

```
137     }
138
139     /**
140     * Caluclates the factorial of n
141     * @param n number to calculate the factorial of
142     * @return n!
143     */
144     private static double fact(double n) {
145         //If n = 0 or 1, n! defaults to 1
146         double result = 1;
147         //Otherwise i is multiplied to result until n is reached.
148         for (int i = 2; i <= n; i++) {
149             result *= i;
150         }
151
152         return result;
153     }
154 }
```

# Task 9

## Sum of Fibonacci Sequence

*Assumption: The first term is 0 to form the sequence 0, 1, 1, 2, 3, 5, ...*

Input $n$	Expected Output	Actual Output
1	0	0
2	1	1
3	2	2
4	4	4
50	$2.03650 \times 10^{10}$	$2.03650 \times 10^{10}$
100	$5.73148 \times 10^{20}$	$5.73148 \times 10^{20}$
178	$1.14631 \times 10^{37}$	$1.14631 \times 10^{37}$
200	$4.53974 \times 10^{41}$	$4.53974 \times 10^{41}$
300	$3.59579 \times 10^{62}$	$3.59579 \times 10^{62}$
500	$2.25592 \times 10^{104}$	$2.25592 \times 10^{104}$
1000	$7.03304 \times 10^{208}$	$.03304 \times 10^{208}$
1475	$1.30699 \times 10^{308}$	$1.30699 \times 10^{308}$
1476	$2.11475 \times 10^{308}$	Infinity <sup>1</sup>
-1	Your input was not accepted. Please try again Please input the number of terms to calculate the sum of:	Your input was not accepted. Please try again Please input the number of terms to calculate the sum of:
-5	Your input was not accepted. Please try again Please input the number of terms to calculate the sum of:	Your input was not accepted. Please try again Please input the number of terms to calculate the sum of:
Test	Your input was not accepted. Please try again Please input the number of terms to calculate the sum of:	Your input was not accepted. Please try again Please input the number of terms to calculate the sum of:

<sup>1</sup>This was produced due to the limitations of the `double` data type that was used. As a result, for all  $n \geq 1476$  will result in an output of "Infinity"

## 9.1 The source code for Task 9

```

1 import java.util.InputMismatchException;
2 import java.util.Scanner;
3
4 /**
5  * @author Mark Said Camilleri
6  * @version 20160523
7  */
8 public class Question9 {
9     public static void main(String[] args) {
10         /*===== WELCOME USER =====*/
11         System.out.println("
12         -----");
13         System.out.println("|      CSA 1017 - Data Structures and
14         Algorithms 1      |");
15         System.out.println("
16         |-----|");
17         System.out.println("|              Submission by Mark Said Camilleri
18         |");
19         System.out.println("|              Task 9: Sum of Fibonacci Sequence
20         |");
21         System.out.println("
22         |-----|");
23
24         /*===== ASK USER FOR INPUT =====*/
25         Scanner in = new Scanner(System.in);
26         int n = -1;
27
28         do {
29             //Asks user for number of terms
30             System.out.println("| Please input the number of terms to
31             calculate the |");
32             System.out.print("| sum of: ");
33
34             try {
35                 n = in.nextInt();
36
37                 //Only accept positive integers for this.
38                 if (n < 1) {
39                     System.out.println("| Your input was not accepted.
40                     Please try again |");
41                 }
42             } catch (InputMismatchException ime) {
43                 //If input is wrong
44                 System.out.println("| Your input was not accepted.
45                 Please try again |");
46                 n = 0;
47                 in.nextLine();
48             }
49         } while (n < 1);
50
51         double result = fibsum(n);
52         System.out.printf("| The sum to the first %-5d terms is: %-12g
53         |\n", n, result);

```

```
44     System.out.println("-----");
45     -----");
46 }
47
48 /**
49  * Method that returns the sum of the fibonacci numbers up to
50  * and including the nth term.
51  *
52  * @param n The number of terms of fibonacci sequence to find the
53  *          sum of
54  * @return The sum of the fibonacci numbers up to and including
55  *         the nth term
56  */
57 public static double fibsum(int n) {
58     /*
59      * 1st and 2nd term respectively these are (i-2)th and
60      * (i-1)th terms respectively.
61      */
62     double fib1 = 0;
63     double fib2 = 1;
64
65     //Base cases, since the pattern is based on the first 2 terms.
66     if (n == 1) return fib1;
67     else if (n == 2) return fib2;
68     else {
69         //Result of the sum of the first 2 terms, to add to it.
70         double result = 1;
71         for (int i = 3; i <= n; i++) {
72             //ith term of fib sequence
73             double fib = fib1 + fib2;
74             result += fib;
75
76             //Shifts (i-1)th term to (i-2)th term
77             fib1 = fib2;
78             //Shifts ith term to (i-1)th term
79             fib2 = fib;
80         }
81         //Sum of fibonacci sequence is returned
82         return result;
83     }
84 }
85 }
```