

# Test Plan for the Companion Cube Calculator ( $C^3$ ) Tool

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# 1 Revision History

Date	Version	Notes
	1.0	Initial draft completed

## 2 Symbols, Abbreviations and Acronyms

Symbol	Description
$C^3$	Companion Cube Calculator
SRS	Software Requirements Specification
T	Test

[symbols, abbreviations or acronyms – you can reference the SRS tables if needed —SS]

# Contents

<b>1</b>	<b>Revision History</b>	<b>i</b>
<b>2</b>	<b>Symbols, Abbreviations and Acronyms</b>	<b>ii</b>
<b>3</b>	<b>General Information</b>	<b>1</b>
3.1	Purpose . . . . .	1
3.2	Scope . . . . .	1
3.3	Overview of Document . . . . .	2
<b>4</b>	<b>Plan</b>	<b>2</b>
4.1	Software Description . . . . .	2
4.2	Test Team . . . . .	2
4.3	Automated Testing Approach . . . . .	3
4.4	Verification Tools . . . . .	3
4.5	Non-Testing Based Verification . . . . .	3
<b>5</b>	<b>System Test Description</b>	<b>3</b>
5.1	Tests for Functional Requirements . . . . .	3
5.1.1	Getting User Inputs . . . . .	3
5.1.2	Conditioning User Inputs . . . . .	6
5.1.3	Verifying Data Constraints . . . . .	10
5.2	Tests for Non-Functional Requirements . . . . .	12
5.2.1	Area of Testing1 . . . . .	12
5.2.2	Area of Testing2 . . . . .	12
5.3	Traceability Between Test Cases and Requirements . . . . .	12
<b>6</b>	<b>Unit Testing Plan</b>	<b>12</b>
<b>7</b>	<b>Appendix</b>	<b>13</b>
7.1	Symbolic Parameters . . . . .	13
7.2	Usability Survey Questions? . . . . .	13

## List of Tables

## List of Figures

## 3 General Information

This document is a software test plan for the Companion Cube Calculator ( $C^3$ ), a mathematical tool which determines the range,  $R(f(X))$ , of a user-specified function,  $f(X)$ , given the domains of the function's variables,  $D(X)$ . The calculations are performed using interval arithmetic.

### 3.1 Purpose

This document describes the software test plan for the  $C^3$  tool and is informed by its SRS documentation (version 1.0.1), including a description of automated testing approach, tools, and black box test cases. The purpose of documenting this information is to guide the product testing for the initial product release and to provide a basis for regression testing as further developments are made to the  $C^3$  tool.

This document is intended for readers who wish to test the initial version of the product, as well as those who want to refine and expand the tool. As changes are made to the  $C^3$  tool, these test cases will form the foundation of regression testing and will help ensure that any changes made to the product do not affect its original purpose or core functionality.

This test plan is intended to be used for version 1.0 of the  $C^3$  tool, and will only contain test information related to the product description in the product's SRS documentation (version 1.0.1). Any functionality defined beyond the scope of the SRS document are not included in this version of the test plan.

### 3.2 Scope

The  $C^3$  tool relies on interval arithmetic in the domain of real numbers ( $\mathbb{R}$ ), which means that many of its functions can be empirically tested. The tool has not yet been built, so the plan not include implementation-specific tests. Instead, this plan will outline black box tests that abstracts the tool into modules based on the requirements identified in the SRS documentation.

The purpose of this plan is to guide the modularization of the  $C^3$  tool design so that it is easy to test and maintain. It also forms the foundation of the kinds of behaviours that the tool should exhibit when it encounters malformed user inputs and unexpected values during its calculations.

### **3.3 Overview of Document**

This document presents a general description of the  $C^3$  tool to establish the context of the test plan and a list of team members responsible for executing it. This background information is followed by a high-level description of the test plan, including the automated testing approach, verification tools, and non-testing based verification methods that will be used. The general plan outline is followed by a description of the system test which is designed to determine if the requirements from the associated SRS document are satisfied. The final section describes how unit testing will be implemented when the internal workings of the  $C^3$  tool are established.

## **4 Plan**

This section describes the test plan for the  $C^3$  tool from a high-level perspective, outlining the methodologies and tools that will be used during the verification process, and the team responsible for executing the plan.

### **4.1 Software Description**

The  $C^3$  tool is a stand-alone application for calculating the mathematical range of a user-defined function given the domains of the function's component variables. Function ranges and variable domains are represented by intervals, where intervals are defined as a sequence of continuous values bounded by a minimum and maximum value. The minimum and maximum values for any given interval must be defined. To perform its calculations, the  $C^3$  tool uses interval mathematics.

The purpose of this product is to produce accurate results when they can be found. If a result cannot be found, the tool is expected to communicate the reason back to the user. Calculations must be accurate within an error range of the host machine's floating point error. These tasks must be completed while presenting all communications to the user in standard function and interval notation.

### **4.2 Test Team**

The test team assigned to implement this plan is Geneva Smith.

### 4.3 Automated Testing Approach

### 4.4 Verification Tools

[Thoughts on what tools to use, such as the following: unit testing framework, valgrind, static analyzer, make, continuous integration, test coverage tool, etc. — SS]

### 4.5 Non-Testing Based Verification

[List any approaches like code inspection, code walkthrough, symbolic execution etc. Enter not applicable if that is the case. —SS]

## 5 System Test Description

The system testing of the  $C^3$  tool will focus on inspecting and conditioning user inputs and ensuring that the  $C^3$  tool is able to produce descriptive outputs for both valid and invalid inputs.

The goal of user input inspection and conditioning tests is to be sure that the  $C^3$  tool is able to identify and reject values that violate the assumptions. If the tool determines that the values do not violate the assumptions, it should be able to convert those values into the internal representations identified in the SRS document. For the purposes of this test plan, it is assumed that the user function  $f(X)$  is represented internally as a parse tree.

Even if the user inputs are validated and conditioned correctly, it is still possible for the  $C^3$  tool to encounter invalid operations in an intermediary step while calculating a result. This makes it necessary to create a series of tests to determine how the tool will react to both supported and unsupported operations.

### 5.1 Tests for Functional Requirements

#### 5.1.1 Getting User Inputs

This test suite is designed to determine if the ?? functional requirement is satisfied.

#### User Inputs (As Expected)



1. test-directinput

Type: Functional

Initial State: New Session

Input:  $f(X) = x + y, x = [2, 4], y = [2, 4]$

Output: Input received from direct input

How test will be performed: Unit Test

2. test-fileinput

Type: Functional

Initial State: New Session

Input: File containing:  $f(X) = x + y, x = [2, 4], y = [2, 4]$

Output: Input received from file

How test will be performed: Unit Test

3. test-badFileInput

Type: Functional

Initial State: New Session

Input: File that cannot be read

Output: Error – File cannot be read

How test will be performed: Unit Test

**User Inputs (Function is a Constant Value)**

1. test-input\_functionAsConstant

Type: Functional

Initial State: New Session

Input:  $f(X) = 34$

Output: N/A

How test will be performed: Unit Test

### **User Inputs (Extraneous Information)**

1. test-input\_variableNotInFunction

Type: Functional

Initial State: New Session

Input:  $f(X) = 34$ ,  $x = [2, 4]$

Output: Warning – Function  $f(X)$  does not contain name  $x$  found in variable list

How test will be performed: Unit Test

### **User Inputs (Missing Values)**

1. test-input\_noFunction

Type: Functional

Initial State: New Session

Input:  $x = [2, 4]$ ,  $y = [2, 4]$

Output: Error – Could not find function  $f(X)$  with variables  $x, y$

How test will be performed: Unit Test

### **User Inputs (Incomplete Values)**

1. test-input\_missingFunctionValue

Type: Functional

Initial State: New Session

Input:  $f(X) = x+$ ,  $x = [2, 4]$ ,  $y = [3, 5]$

Output: Error – Function  $f(X)$  is missing an operand for +

How test will be performed: Unit Test

2. test-input\_missingMinDomainValue

Type: Functional

Initial State: New Session

Input:  $f(X) = x + y$ ,  $x = [, 4]$ ,  $y = [3, 5]$

Output: Error – Missing min domain value for  $x$

How test will be performed: Unit Test

3. test-input\_missingMaxDomainValue

Type: Functional

Initial State: New Session

Input:  $\{f(X) = x + y, x = [2, 4], y = [3, ]\}, \{f(X) = x + y, x = [2, 4], y = [3]\}$

Output: Error – Missing max domain value for  $y$

How test will be performed: Unit Test

**User Inputs (Non-Numerical Value in Domains)**

1. test-input\_nonNumberInDomain

Type: Functional

Initial State: New Session

Input:  $f(X) = x + y$ ,  $x = [2, 4]$ ,  $y = [a, 5]$

Output: Error – Non-numerical value found in the domain for variable  $y$

How test will be performed: Unit Test

**5.1.2 Conditioning User Inputs**

This test suite is designed to determine if the ?? and ?? functional requirements are satisfied.

## Parsing User Inputs (Single Operators)

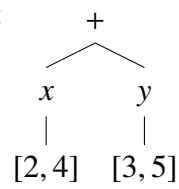
### 1. test-parse\_addition

Type: Functional

Initial State: New Session

Input:  $f(X) = x + y$ ,  $x = [2, 4]$ ,  $y = [3, 5]$

Output:



How test will be performed: Unit Testing

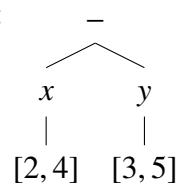
### 2. test-parse\_subtraction

Type: Functional

Initial State: New Session

Input:  $f(X) = x - y$ ,  $x = [2, 4]$ ,  $y = [3, 5]$

Output:



How test will be performed: Unit Testing

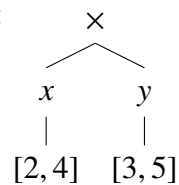
### 3. test-parse\_multiplication

Type: Functional

Initial State: New Session

Input:  $f(X) = x \times y$ ,  $x = [2, 4]$ ,  $y = [3, 5]$

Output:



How test will be performed: Unit Testing

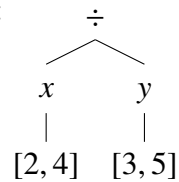
4. test-parse\_division

Type: Functional

Initial State: New Session

Input:  $f(X) = x \div y, x = [2, 4], y = [3, 5]$

Output:



How test will be performed: Unit Testing

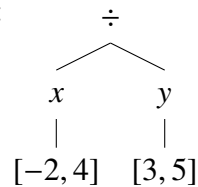
5. test-parse\_divisionMixedIntervalQuotient

Type: Functional

Initial State: New Session

Input:  $f(X) = x \div y, x = [-2, 4], y = [3, 5]$

Output:



How test will be performed: Unit Testing

6. test-parse\_divisionMixedIntervalDivisor

Type: Functional

Initial State: New Session

Input:  $f(X) = x \div y, x = [2, 4], y = [-3, 5]$

Output: Error – Cannot perform division with a mixed interval divisor

How test will be performed: Unit Testing

7. test-parse\_intervalAsExponents

Type: Functional

Initial State: New Session

Input:  $f(X) = 2^x$ ,  $x = [2, 4]$

Output: 
$$\begin{array}{c} \wedge \\ 2 \quad x \\ | \\ [2, 4] \end{array}$$

How test will be performed: Unit Testing

8. test-parse\_intervalWithExponent

Type: Functional

Initial State: New Session

Input:  $f(X) = x^2$ ,  $x = [2, 4]$

Output: 
$$\begin{array}{c} \wedge \\ x \quad 2 \\ | \\ [2, 4] \end{array}$$

How test will be performed: Unit Testing

9. test-parse\_intervalsOnlyExponentiation

Type: Functional

Initial State: New Session

Input:  $f(X) = x^y$ ,  $x = [2, 4]$ ,  $y = [3, 5]$

Output: Error – Cannot perform exponentiation when the base number and the exponent are intervals

How test will be performed: Unit Testing

10. test-parse\_multipleOperatorsInFX

Type: Static

Initial State: New Session

Input:  $R(f(X)) = R(f_1(X)) < op > R(f_2(X))$ , where  $R(f_1(X)), R(f_2(X))$  exist

Output: True

How test will be performed: Induction

11. test-parse\_multipleOperatorsInFX

Type: Static

Initial State: New Session

Input:  $R(f(X)) = R(f_1(X)) < op > R(f_2(X))$ , where  $R(f_1(X))$  or  $R(f_2(X))$  do not exist

Output: Error – Calculation path encountered an unsupported interval operation

How test will be performed: Induction

### 5.1.3 Verifying Data Constraints

This test suite is designed to determine if the ?? functional requirement is satisfied.

#### Domain Constraints

1. test-input\_noDomain

Type: Functional

Initial State: New Session

Input:  $f(X) = x + y, x = [2, 4]$

Output: Error – No domain for variable y

How test will be performed: Unit Test

## Exponentiation Constraints

### 1. test-parse\_intervalAsExponentsInvalidBase

Type: Functional

Initial State: New Session

Input:  $f(X) = 1^x$ ,  $x = [2, 4]$

Output: Error – Cannot perform operation with an interval exponent when the base number ( $b$ )  $\leq 1$

How test will be performed: Unit Testing

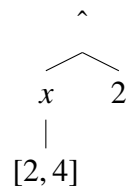
### 2. test-parse\_intervalWithInvalidExponent1

Type: Functional

Initial State: New Session

Input:  $f(X) = x^{2.1}$ ,  $x = [2, 4]$

Output: Warning – Cannot perform operation with an exponent that is not a whole number; the exponent has been rounded to 2



How test will be performed: Unit Testing

### 3. test-parse\_intervalWithInvalidExponent2

Type: Functional

Initial State: New Session

Input:  $f(X) = x^{-1}$ ,  $x = [2, 4]$

Output: Error – Cannot perform operation exponentiation with an exponent  $< 0$

How test will be performed: Unit Testing



## **5.2 Tests for Non-Functional Requirements**

### **5.2.1 Area of Testing1**

#### **Title for Test**

1. test-id1

Type:

Initial State:

Input/Condition:

Output/Result:

How test will be performed:

2. test-id2

Type: Functional, Dynamic, Manual, Static etc.

Initial State:

Input:

Output:

How test will be performed:

### **5.2.2 Area of Testing2**

...

## **5.3 Traceability Between Test Cases and Requirements**

# **6 Unit Testing Plan**

[Unit testing plans for internal functions and, if appropriate, output files —SS]

## **References**

## **7 Appendix**

This is where you can place additional information.

### **7.1 Symbolic Parameters**

The definition of the test cases will call for `SYMBOLIC_CONSTANTS`. Their values are defined in this section for easy maintenance.

### **7.2 Usability Survey Questions?**

This is a section that would be appropriate for some teams.