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CMP-6048A Advanced Programming

Project Report - 15 December 2021

Maths Interpreter Software

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Version 1.0

## **Abstract**

An abstract is a brief summary (maximum 250 words) of your entire project. It should cover your objectives, your methodology used, how you implemented the methodology for your specific results and what your final results are, your final outcome or deliverable and conclusion. You do not cover literature reviews or background in an abstract nor should you use abbreviations or acronyms. In the remainder of the report the chapter titles are suggestions and can be changed (or you can add more chapters if you wish to do so). This template is designed to help you write a clear report but you are welcome to modify it (at your peril ...). Finally, a guideline in size is approximately 3,500 words (not including abstract, captions and references) but no real limit on figures, tables, etc.

# Chapter 1

## Introduction

### 1.1 Project statement

The purpose of this project is to create a piece of software that is an interpreter for mathematical functions. It will run both as an interactive prompt and a utility to interpret and execute pre-written files. It will additionally provide the ability to visualise mathematical functions such as on a graph.

### 1.2 MoSCoW

#### 1.2.1 Musts

These elements largely comprise the minimum functional requirements of the program and are as such the most necessary items.

- Expressions
- Statements
- Commands
- Custom syntax using a custom lexer and parser

#### 1.2.2 Shoulds

- Function visualisation
- Intuitive UI
- Flexible and scalable architecture
- Parallel processing of intensive operations
- Simple trigonometric functions

#### 1.2.3 Coulds

- Interactive visualisations
- Zero-crossings finder
- Differentiation and integration of functions
- Simple equation solver (for example finding a variable)

#### **1.2.4 Won'ts**

- Imaginary numbers
- 3D function graphing
- Multi-variable equation solver (beyond simple simultaneous equations)

### **1.3 Report structure**

Briefly describe what you will cover in the remainder of the report, chapter by chapter.

# Chapter 2

## Background

To better understand what we do and don't want from our software, we analysed systems on the market that have a similar function to our own. We analysed the good and bad features of each and identified any we would take forward into our own product.

### 2.1 Similar Systems

#### 2.1.1 MATLAB[1]

MATLAB is a standalone piece of mathematical software designed with a focus on manipulation of mathematical data types such as matrices as well as including generic programming. It is a Turing complete language, so it has a very wide range of possible uses, but it is very much geared towards easily running numeric calculations. It has its own syntax, which means that users will have to learn it, but the custom syntax it uses is very similar to many popular programming languages, and so users with that background may find transitioning easier. From this program, we like the layout of the user interface. It is intuitive and everything you need is in easy reach. This is the sort of UI we would like to implement in our own product. However, this program takes up a lot of storage and does not run well on lower specification machines. We would like our own product to be able to run on most desktop devices so it is more accessible.

#### 2.1.2 Math Inspector[2]

Math Inspector is a package of addons for Python which allow for mathematical functions to be graphically visualised, both by displaying a flow-type diagram of the function as well as graphing the numeric outputs across a range. Since it is an addon for Python, people who are familiar with the language already shouldn't have much difficulty using it. It may, however, mean that people have to install more than what they need in order to get it to run. Whilst the Python basis may make it easier for some people, many who wish to use this program will have no prior Python knowledge. For this reason, we feel the benefits of a familiar language are outweighed by the cost of having to install the extra programs. Therefore, we will not be doing something similar in our own system.

#### 2.1.3 Wolfram Mathematica[3]

Wolfram Mathematica is an interactive tool used to define and visualise mathematical functions. Its main focus is using technology to visualise mathematics and to allow the user to directly implement a vast variety of features. It offers over 5000 different in-built maths functions, meaning it contains very few restrictions. It runs on its own in-built language which may take the user some time to learn and become familiar with. Its main strength is definitely its advanced visualisation features. The vast variety of tools it offers is nice but will be a waste for most people. For our system, we will focus on the most common maths functions to maximise use whilst minimising memory cost. In the future,

our system could use addons to cover more areas of mathematics without the user having to install hundreds of tools they will never need.

#### **2.1.4 Maple[4]**

Maple offers a number of different versions of its' software allowing the user to tailor their experience before they even download. It's main goal is solving equations but it still offers an intuitive UI with function visualisation features. It allows the user to explore a range of mathematical fields by offering a large variety of in-built functions. Similarly to the previous system, it operates using its own programming language which may take users time to learn and understand. The different versions of the software (tailored based on who is using it) is this systems' main strength. Our system should also include an intuitive user interface. The different systems versions are a definite positive and something we would take forward in future versions of our product. For now, our product will focus on the most commonly used areas of mathematics to maximise usability.

# Chapter 3

## Methodology

Describe here various methods that will be used in your project. Use different sections for distinctly different subjects and use subsections for specific details on the same subject. Only use subsubsections or paragraphs (which are not numbered) if you believe this is really necessary. Since implementation will happen in sprints, this section may need several updates with parts being added and deleted across the project.

### 3.1 Method 1

#### 3.1.1 Method 1 specific detail 1

In case you need maths, here is an example to write an equation:

$$\int_{\Omega_0} \delta u \frac{\partial \mathbf{P}}{\partial X} d\Omega_0 + \int_{\Omega_0} \delta u \mathbf{b} d\Omega_0 + \int_{\Omega_0} \delta u \rho_0 \ddot{\mathbf{u}} d\Omega_0 = 0 \quad (3.1)$$

And here we show how to write a matrix equation:

$$\mathbf{X} \frac{\partial N}{\partial e_c} = \begin{bmatrix} x_1 & x_2 & x_3 & x_4 \\ y_1 & y_2 & y_3 & y_4 \\ z_1 & z_2 & z_3 & z_4 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -1 & -1 \end{bmatrix} \quad (3.2)$$

#### 3.1.2 Method 1 specific detail 2

blablabla

b lablabla

### 3.2 Method 2

#### 3.2.1 Method 2 specific detail 1

#### 3.3 Etc.

##### 3.3.1 Etc.

# Chapter 4

## Implementation

In this chapter you cover the actual implementation of your project. Implementation will be done in sprints so you may wish to use different sub-sections for each sprint and then dedicate a section to your final deliverable. Section ?? with figures should not remain in the final report.

### 4.1 Early sprints

#### 4.1.1 Sprint 1

For our first sprint, we defined the following set of requirements:

1. Create the program skeleton we can build upon
2. Build the Lexer and parser for our language
3. Allow the program to identify integers
4. Allow the program to recognize basic operators, including addition, multiplication, subtraction, division and brackets
5. The program should be able to execute the basic operation is can identify

#### Requirement 1:

The program now contains the different classes it will need to run. These include the Lexer Class which is the class used to identify the different tokens, The parser class that checks the syntax of the languages and the execution class that runs through the stack and performs the operations held there in the correct order. There is also the main class that is responsible for the input display and parsing that input to the Lexer.

#### Requirement 2:

Once all the classes were created, we were able to build the Lexer and parser for our language. The Lexer can correctly identify integers, plus signs, minus signs, multiplication and division signs and brackets as well as ignoring blank space. The only limitation of our current Lexer is that it is unable to handle integer outside of the integer limit imposed by Java.

The parser can check the syntax of the language by making sure the tokens are written the correct order and lets the user know if there is an issue.

#### Requirement 3:

When the Lexer encounters a digit character, a loop begins and checks each concurrent characters' digit status. If the next character is a digit also, the loop continues. When the Lexer encounters a non-digit character, the loop ends and a number token is added to



the token array and the string of digits is converted into a numerical representation which is put into the symbol table. The symbol table is implemented as a map. The index key for the numeric value is the index in the array of the corresponding number token.

#### **Requirement 4:**

The recognition of basic operators works in the same manner as the integer recognition except without the need for a looping function. Each operator is assigned a given token which is added to the token array upon recognition.

#### **Requirement 5:**

Each token from the token array is copied onto the operator stack and the integers corresponding to the number tokens are copied onto the number stack from the symbol table. When a complete expression has been transferred onto the stack, it will be evaluated and the result of that expression will replace the operands used on the number stack. Any operators used are removed from the stack. Tokens will then continue to be copied onto the two stacks until the end of the token array is reached.

When the program encounters a right bracket, we know a left bracket must exist on the stack as the parser has validated the code. This means that when a right bracket is encountered, the program continually runs calculate until the left bracket reaches the top of the stack. This ensures the number at the top of the number stack is the evaluation of the expression within brackets, ensuring the order of operations is preserved.

#### **4.1.2 Sprint n**

### **4.2 Final implementation**

### **4.3 Figures, tables, etc.**

The purpose of this section is to just show you how to integrate figures, tables, etc. and should disappear in the final report. Figures and tables should be distributed across the document wherever they are needed but you should use an appendix if they are many figures/tables of the same kind. Fig.

Note that code snippets or lists of crucial programming code or large UML diagrams should go in the Appendix/Appendices.

	S-D		L-P old		L-P new	
Diameter	length	strain	length	strain	length	strain
<i>MaVD</i>	140.5	+1.90	129.3	+0.30	129.3	+1.43
<i>OrOD</i>	131.4	+0.10	-	-	119.9	+1.85
<i>OrVD</i>	126.9	+2.20	119.3	+0.25	119.3	+1.24
<i>OFD</i>	134.0	+0.40	-	-	119.7	+1.82
<i>SOFD</i>	-	-	-	-	113.2	-0.85
<i>SOBD</i>	117.1	-1.70	88.7	-1.07	88.7	-2.52
<i>BPD</i>	105.0	0.00	89.7	-0.21	89.7	-0.83

# Chapter 5

## Testing

This section details the testing we performed at the end of each sprint to make sure we meet each of the requirements set out at the beginning of the sprint.

### 5.0.1 Sprint 1

Test No.	Test Case	Test Data	Result
1	The program is able to identify a number	5 83 324876312487124	PASSED PASSED FAILED
2	The program can identify and evaluate an addition expression	5+5 54+6 2+7	PASSED PASSED PASSED
3	The program can identify and evaluate a subtraction expression	5-5 18-9 4-0	PASSED PASSED PASSED
4	The program can identify and evaluate a multiplication expression	5*5 4*7 32*8	PASSED PASSED PASSED
5	The program can identify and evaluate a division expression	5/5 42*7 100/10	PASSED PASSED PASSED
6	The program can evaluate expressions that include blank space	5 + 5 10 - 8 32 - 23	PASSED PASSED PASSED
7	The program can identify and evaluate expression with multiple operators	4+7-2 23+6+4 1*8/4	PASSED PASSED PASSED
8	The program can identify and handle incorrect syntax	5+ 5+(5 *8	PASSED PASSED PASSED
9	The program can identify and evaluate expression involving brackets	5+(4-2+3) (4*2)+7 10/5+(6*8)	PASSED PASSED PASSED

## Chapter 6

# Discussion, conclusion and future work

Briefly discuss and conclude your achievements and put them in perspective with the MoSCoW analysis you did early on. Be honest by declaring for example ‘S’ categorised objectives which did not make it to the final deliverable rather than reversely modifying your MoSCoW in Chapter 1! Also discuss future developments and how you see the deliverable improving if more time could be spent. Note that this section should not be used as a medium to vent frustrations on whatever did not work out (pandemic, group partners, etc.) as there are other means for this (labs, e-mail MO, ...) that should be used well before any such problems become an issue.

# Bibliography

- [1] MathWorks, Natick, Massachusetts, United States. *MATLAB*, 2017.
- [2] *Math Inspector*, 2021.
- [3] Wolfram, The Wolfram Centre, Lower Road, Long Hanborough, Oxfordshire OX29 8FD, United Kingdom. *Wolfram Mathematica*, 2021.
- [4] Maplesoft, 615 Kumpf Drive, Waterloo, ON, Canada, N2V 1K8. *Maple*, 2021.
- [5] B. Sorbe and S. Dahlgren. Some important factors in the molding of the fetal head during vaginal delivery - a photographic study. *International Journal of Gynecology & Obstetrics*, 21(3):205–212, 1983.
- [6] R. J. Lapeer and R. W. Prager. Fetal head moulding: finite element analysis of a fetal skull subjected to uterine pressures during the first stage of labour. *Journal of Biomechanics*, 34(9):1125–1133, September 2001.

# Contributions

State here the % contribution to the project of each individual member of the group and describe in brief what each member has done (if this corresponds to particular sections in the report then please specify these).

# Appendix A

Put in tables of data or protocols (e.g. for testing) or code listings or UML diagrams which may take up several pages and do not sit well in the main body text.