KOLEJ UNIVERSITI TUNKU ABDUL RAHMAN
FACULTY OF COMPUTING AND INFORMATION TECHNOLOGY

Assignment Final Report

BACS1024 Introduction to Computer Systems

Oct 2020 Semester

Student's name   : (1)TEO WEN ZHI   (2)WONG WINNIE

Student's ID number   : (1)20WMR09522   (2)20WMR09192

Programme & Group   : **RSF2 Group 7**

Date of Submission   : 30 NOVEMBER 2020

Student	Part 1	Part 2					Total / Grade
	10	10	10	15	15	15	75 marks
(1)TEO WEN ZHI							
(2)WONG WINNIE							
Comment:							

Plagiarism Statement

The Faculty of Computing and Information Technology views cases of plagiarism or collusion by students very seriously. Any students who intentionally plagiarize or collude in any part of their assignments/projects or written work threatens the values of academic work and undermines the credibility and integrity of the University College's awards. Plagiarism or collusion discovered at any stage of the student's course of study will be dealt with appropriately by the School. Such offender shall appear before a panel of enquiry at the Faculty and appropriate punishment will be meted out. Punishment may include failing the student for the assignment or project, re-submission of another piece of work or downgrading of the work to the maximum of a pass grade even if the actual grade achieved was higher.

What constitutes "Plagiarism" and "Collusion"?
Plagiarism according to the Oxford Advanced Learner's Dictionary of Current English means "take and use somebody else's ideas, words, etc as if they were one's own."

Plagiarism can take the form of reproduction without acknowledgement from published or unpublished works of others including materials downloaded from computer files on the Internet.

Student's work submitted for assessment is accepted on understanding that it is the students' own effort without falsification of any kind. Acknowledgement to the source must be made if students had relied on any sources for information with appropriate reference being made in their work.

Collusion can be deemed to be a form of plagiarism involving the unauthorized co-operation between two or more people with deceptive intention.

Collusion can take the form of two or more students producing a piece of work together but with one intentionally passing it off as his work with the knowledge of the others. Student may have submitted the work of another as his own with consent from that other student. In such cases, both parties are guilty of collusion.

Obligations of students
Students are required to sign a declaration statement that the work submitted such as coursework assignment, essays and projects, etc is their own work and that they have not in any way knowingly allow another student to
copy it. It will be assumed that all submitted work is that of the students' own work.

Students are expected to familiarize themselves with or make use of method(s) of citing other people's work in accordance with acceptable referencing.

Read, complete and sign this statement to be submitted with written work.

I / we confirm that I /we have read and shall comply with all the terms and conditions of TAR University College's plagiarism policy.

I / we declare that this submitted work is free from all forms of plagiarism and for all intents and purposes is my own properly derived work.

Student's Signature	(1)	(2)
Student's Name	(1)TEO WEN ZHI	(2)WONG WINNIE
Student's ID number	(1)20WMR09522	(2)20WMR09192
Date	30 NOVEMBER 2020	

Table of content

Proposal

(a)

Member's Name	Student ID
Teo Wen Zhi	20WMR09522
Wong Winnie	20WMR09192

(b) Proposed system title / name - Multifunctional calculator

(c) System synopsis (WH-Q)
      This multifunctional calculator is a system designed and created by students Teo Wen Zhi and Wong Winnie using 8086 assembly language and run by DOSbox 0.74. This calculator has different calculation methods which can be divided into 4 different main functions: base conversion & calculation, , area/volume calculation, fraction calculation and statistics calculation. This system is created to allow users to perform different operations by inputting operands into the calculator.

(d) Justifications on proposal / benefits
      With this multifunctional calculator, the user is able to choose a variety of important functions that are used in many fields and perform the calculations, conversions and different operations needed efficiently. Crucial features like base conversion and calculation are useful for programming and coding, area/volume calculation is essential for visual graphics, modelling and architectural design, whereas fraction and statistics calculation are convenient for data analysis, mathematical equations, research etc.

(e) System functions / features (at least 2 functions per person)
- Base conversion & calculation
- Area/volume calculation
- Fraction calculation
- Statistics calculation

(f) Mathematical formula(s) involved.

1. Base conversion & calculation
   - Conversion from BIN to HEX.
   - Conversion from HEX to DEC.
   - Calculation(Addition, Subtraction, Multiplication, Division) for HEX.
   - Calculation(Addition, Subtraction, Multiplication, Division) for BIN.

2. Area/volume calculation
   <u>Area</u>
   - Rectangle = height * width
   - Triangle = height * base / 2
   - Circle = PI * radius^2
   <u>Volume</u>
   - Cube = length^3
   - Cuboid = length * height * width
   - Sphere = 4/3 * PI * radius^3
   - Pyramid = (length * height * width) /3
   - Cylinder = PI * radius^2 * height
   - Cone = (PI * radius^2 * height) /3

3. Fraction calculation
   - Addition for Fraction
   - Subtraction for Fraction
   - Multiplication for Fraction
   - Division for Fraction
   - Conversion to decimal points
   - Support bracket calculation

4. Statistics calculation
   - Sum,mean, median, mode
   - Standard deviation, variance
   - Largest, smallest

$\mathrm{Med}(X) = \begin{cases} X[\frac{n}{2}] & \text{if } n \text{ is eve} \\ \frac{(X[\frac{n-1}{2}]+X[\frac{n+1}{2}])}{2} & \text{if } n \text{ is odd} \end{cases}$	$A = \dfrac{1}{n}\displaystyle\sum_{i=1}^{n} a_i$
$\sigma^2 = \dfrac{\Sigma\,(x-\mu)^2}{N}$ **Population Variance** $s^2 = \dfrac{\Sigma\,(x-\bar{x})^2}{n-1}$ **Sample Variance**	Newton's Method X(n+1)=(Xn+a/Xn) /2

(g) Business / process rules / limits

Limit on Base Conversion
- The maximum range for user input is 16 bit binary for BIN to HEX base conversion (0000 0000 0000 0000B - 1111 1111 1111 1111B).
- The maximum range for user input is 16 bit hexadecimal for HEX to DEC base conversion (0000H - FFFFH).
- No floating point for input is allowed.
- Maximum output value is equivalent to 65535 in base-10.
- Negative value not allowed.

Limit on Base Calculation
- The maximum range for user input is 16 bit hexadecimal for HEX addition function. (0000H - FFFFH).
- The maximum range for user input is 16 bit hexadecimal for HEX subtraction function. (0000H - FFFFH).
- The maximum range for user input is 8 bit hexadecimal for HEX multiplication function. (00H - FFH).
- The maximum range for user input is 16 bit hexadecimal for HEX division function. (0000H - FFFFH).
- The maximum range for user input is 16 bit binary for BIN addition function. (0000 0000 0000 0000B - 1111 1111 1111 1111B).
- The maximum range for user input is 16 bit binary for BIN subtraction function. (0000 0000 0000 0000B - 1111 1111 1111 1111B).
- The maximum range for user input is 8 bit binary for BIN multiplication function. (0000 0000B - 1111 1111B).

- The maximum range for user input is 16 bit binary for BIN division function. (0000 0000 0000 0000B - 1111 1111 1111 1111B).
- Zero value is not allowed as a divisor (2nd operand) for HEX and BIN division function.
- No floating point for input is allowed.
- Maximum output value is equivalent to 65535 in base-10.
- Negative value not allowed.

Limit on Area/Volume Calculation
- The maximum range for user input is 1-255 for rectangle area calculation function.
- The maximum range for user input is 1-362 for triangle area calculation function.
- The maximum range for user input is 1-144 for circle area calculation function.
- The maximum range for user input is 1-40 for cube volume calculation function.
- The maximum range for user input is 1-40 for cuboid volume calculation function.
- The maximum range for user input is 1-14 for sphere volume calculation function.
- The maximum range for user input is 1-58 for pyramid volume calculation function.
- The maximum range for user input is 1-27 for cylinder volume calculation function.
- The maximum range for user input is 1-39 for cone volume calculation function.
- No floating point for input is allowed.
- Maximum output value is equivalent to 65535 in base-10.
- Maximum output for floating point is 2.
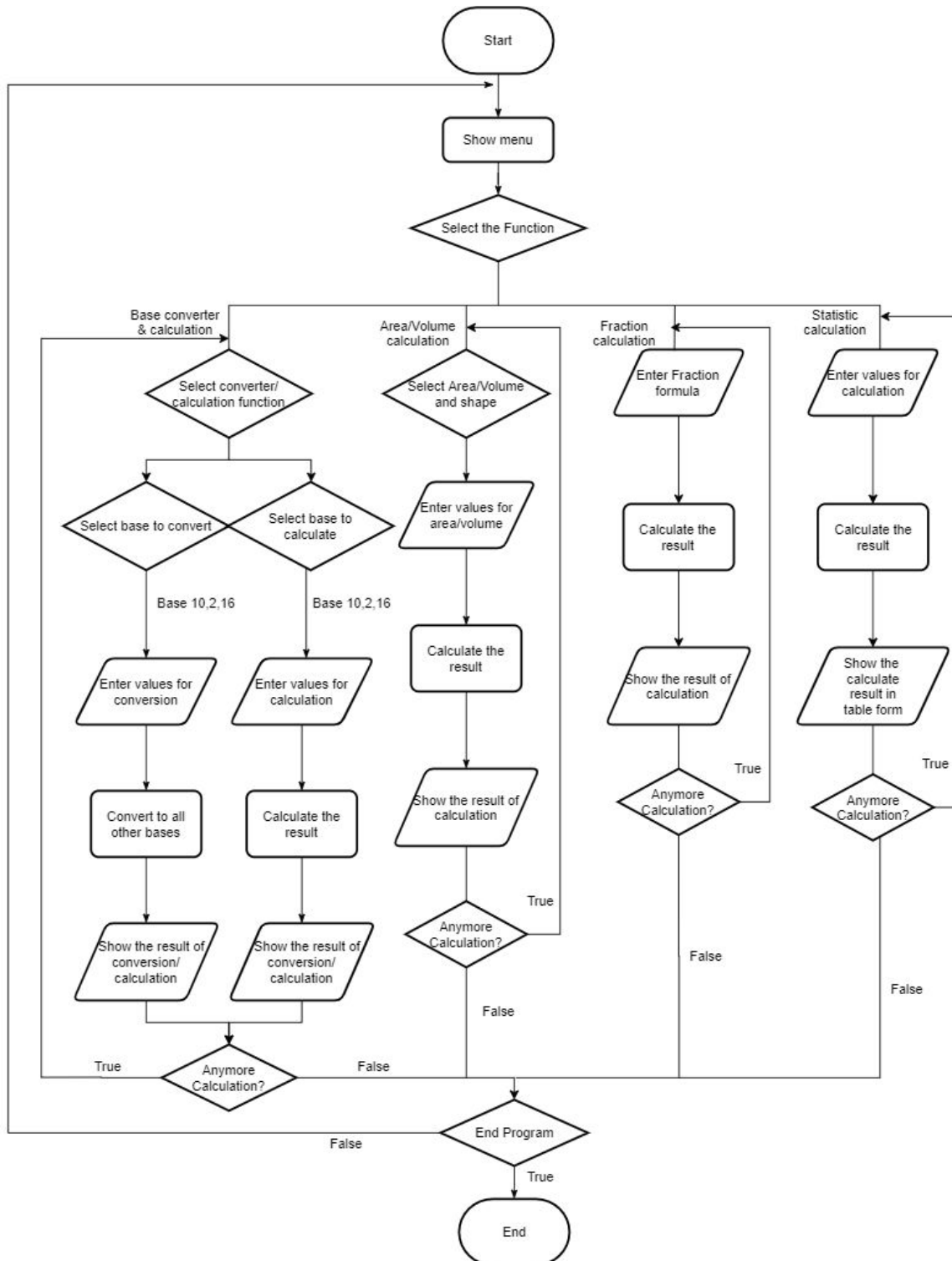- Negative value not allowed.

Limit on Fraction Calculation
- The maximum range of calculation of fraction is within denominator (4-digit) and numerator (4-digit), meaning **max=9999/9999,min=0**, if over this limit some calculation might not be done.

- This calculation allowed enter the informal, formal, mixed fraction and whole number, but the floating point is not allowed

- If your denominator is different please make sure the multiplication of denominators is **not over 65535**. For example, $\frac{1}{250} + \frac{1}{260}$ the result of 250*260 is 65000 still acceptable. But if your formulas is something like $\frac{1}{300} + \frac{1}{310}$ the result of 300*310 is 93000 is not acceptable.

- The calculation of fraction not includes the negative operation, but the negative result is acceptable. for example, 80-90=-10

- This calculator will not have the validation on overflow if your result is over +65535 and -32768 no matter the denominator and numerator the result will be wrong. Because this calculator uses an overflow sign to determine and calculate the negative of the result.

- For input the formula '=' is compulsory to represent the end of formula.

Limit on Statistics Calculation
- In the calculation of statistic values in a set should be within 3 digit and 2 decimal point, and each set should not enter more than 10 values

- In the calculation of statistics if the total of each square (x^2) over 65535 will not calculate the variance and standard deviation, it also means that each raw data cannot be over 255. Because 256*256 results will be over the limit of 16bits.

- The error range of all the calculations is +-0.1 except the variance is +-2. Reason stated in section (advanced features- statistics calculator)

(h) Flow chart / business flow / process flow

Start

Show menu

Select the Function

Base converter & calculation

Area/Volume calculation

Fraction calculation

Statistic calculation

Select converter/ calculation function

Select Area/Volume and shape

Enter Fraction formula

Enter values for calculation

Select base to convert

Select base to calculate

Enter values for area/volume

Calculate the result

Calculate the result

Base 10,2,16

Base 10,2,16

Enter values for conversion

Enter values for calculation

Calculate the result

Show the result of calculation

Show the calculate result in table form

Convert to all other bases

Calculate the result

Show the result of calculation

True

True

Show the result of conversion/ calculation

Show the result of conversion/ calculation

Anymore Calculation?

Anymore Calculation?

Anymore Calculation?

True

False

True

Anymore Calculation?

False

False

False

False

End Program

False

True

End

User Guide

Running Environment Guidelines
We suggest you use **DosBox 0.74-3** to run this program, and use **visual studio code** (with extension **"x86 and x86_64 Assembly"**) or notepad++ as assembly code viewer

Main Menu Guidelines
1. The main menu with relevant information is displayed and the user is prompted to select the function.

2. Select 1 for Base conversion/calculation

3. Select 2 for Area/Volume calculation

4. Select 3 for Fraction calculation

5. Select 4 for Statistics calculation

6. Select 5 to exit the program

Base Conversion/Calculation Guidelines
1. Base conversion/calculation menu is displayed and the user is prompted to select the function.
2. Select 1 for base conversion function.
3. Select 2 for base calculation function.
4. Select 3 to exit to the main menu.

- **Base Conversion Guidelines**
    1. Base conversion menu is displayed and the user is prompted to select the function.
    2. Select 1 for BIN to HEX conversion.
    3. Select 2 for HEX to DEC conversion.
    4. Select 3 to exit to the base conversion/calculation menu.
    5. If select BIN to HEX conversion, input 16-bit binary number and press "ENTER"
    6. If select HEX to DEC conversion, input 16-bit hexadecimal number and press "ENTER"
    7. If input is invalid, the user will need to input a valid number again.
    8. If input is valid, the conversion result will be displayed.
    9. After the result is displayed, the system will ask the user if there is anymore calculation. Press "1" for yes, "0" for no.
    10. If "1" (yes), the user will be prompted to input the number for conversion again.
    11. If "0" (no), the user will be brought back to the main menu.

- **Base Calculation Guidelines**
    1. Base calculation menu is displayed and the user is prompted to select the base for the calculation function.
    2. Select 1 for HEX calculation.
    3. Select 2 for BIN calculation.
    4. Select 3 to exit to the base conversion/calculation menu.
    5. After selecting the base, the user is prompted to choose the calculation operation.
    6. Select 1 for addition.
    7. Select 2 for subtraction.
    8. Select 3 for multiplication.
    9. Select 4 for division.
    10. Select 5 to exit to the base calculation menu.

11. After selecting the operation, input the first operand and press "ENTER".
12. Input the second operand and press "ENTER".
13. If input is invalid, the user will need to input a valid number again.
14. If input is valid, the calculation result will be displayed.
15. After the result is displayed, the system will ask the user if there is anymore calculation. Press "1" for yes, "0" for no.
16. If "1" (yes), the user will be prompted to input the number for conversion again.
17. If "0" (no), the user will be brought back to the main menu.

Area/Volume Calculation Guidelines
1. Area/volume calculation menu is displayed and the user is prompted to select the function.
2. Select 1 for area calculation function.
3. Select 2 for volume calculation function.
4. Select 3 to exit to the main menu.

● **Area Calculation Guidelines**
  1. Area calculation menu is displayed and the user is prompted to select the function.
  2. Select 1 for rectangle area calculation.
  3. Select 2 for triangle area calculation.
  4. Select 2 for circle area calculation.
  5. Select 4 to exit to the area/volume calculation menu.
  6. After selecting the area calculation choice, input variable(s) and press "ENTER"
  7. If input is invalid, the user will need to input a valid number again.
  8. If input is valid, the area calculation result will be displayed.
  9. After the result is displayed, the system will ask the user if there is anymore calculation. Press "1" for yes, "0" for no.
  10. If "1" (yes), the user will be prompted to input the number for conversion again.
  11. If "0" (no), the user will be brought back to the main menu.

● **Volume Calculation Guidelines**
  1. Volume calculation menu is displayed and the user is prompted to select the function.
  2. Select 1 for cube volume calculation.
  3. Select 2 for cuboid volume calculation.
  4. Select 3 for sphere volume calculation.
  5. Select 4 for pyramid volume calculation.
  6. Select 5 for cylinder volume calculation.
  7. Select 6 for cone volume calculation.
  8. Select 7 to exit to the area/volume calculation menu.
  9. After selecting the area calculation choice, input variable(s) and press "ENTER"
  10. If input is invalid, the user will need to input a valid number again.
  11. If input is valid, the area calculation result will be displayed.
  12. After the result is displayed, the system will ask the user if there is anymore calculation. Press "1" for yes, "0" for no.
  13. If "1" (yes), the user will be prompted to input the number for conversion again.
  14. If "0" (no), the user will be brought back to the main menu.

Fraction Calculation Guidelines
1. At the start page of Fraction Calculation will prompt all the relevant information.

2. To do the calculation, you need to enter the formula. Your formula can include the whole number (1,2,3…), Mixed Fraction($1\frac{1}{2}$) , formal and informal Fraction($\frac{1}{2}$), paratheness,

Plus(+), Minus(-), Multiply(*), Divide(/). Due to insufficient of simbol (,) will represent the slash between the fraction.

3. After you entered the formula, you need to ensure that the formula entered is end by equal sign(=) to represent the end of your formula.

4. Press "Enter" key to send your formula to do calculations. If your formula is not valid will not do any calculation for them or show a weird result.

5. That will show all the information, then prompt the message. If you want to continue calculating the fraction enter 'Y' else enter other keys to exit the module.

Statistics Calculation Guidelines
1. At the start page of Fraction Calculation will prompt all the relevant information.

2. To do the calculation you need to enter the value of raw data. Each value you entered must be within 3 Digit and 2 decimal places, and the maximum set of values you can enter is 10. If you entered alphapet will recognize as terminate the data entering then the system will directly show the result.

3. If the total square of raw data is more than 65535, that will show a message and the standard deviation and variances will not be calculated.

4. After showing all the information, then prompt the message. If you want to continue calculating the statistics enter 'Y' else enter other keys to exit the module.

Advanced features of each module

Base Conversion & Calculation   **WONG WINNIE**

For the addition calculation, if the addition result is more than 16 bits, **carry value will be detected and printed out**. This is done by using 'Jump if Carry' to check whether the carry flag is set or not. If yes, jump takes place to display the additional carry value. For example, FFFFH + FFFFH = 1 FFFEH.

For the subtraction operation, if the second operand is larger than the first operand, the result is **able to show negative values.** This is performed by comparing both operands and taking the larger value to subtract the smaller value. Then, a negative sign is displayed to indicate that the result is negative. For example, 0000H - 1111H = -1111H.

For the division operation, if the second operand's value is equal to 0, the system **will not accept zero value as the divisor** as this is a math error (Eg. 1000H / 0000H = Math Error). The system will ask the user to input the divisor again before continuing the division operation. This is done by comparing the value of the second operand to 0, checking whether it is a valid divisor or not.

Area/Volume Calculation   **WONG WINNIE**

For area/volume calculation which has floating point in the result calculation, **2 floating points will be calculated and displayed** to the user. This is done by separating the quotient and remainder after applying the area/volume calculation formula. Then, the remainder is multiplied by 100 (for 2 floating points) and divided by all of the values that are divided in the formula earlier which will return the integer to be printed for 2 floating points. For example, Circle Area = PI * radius^2. Radius = 2. Apply to formula : Quotient = 12, Remainder = 4. Take remainder 4 * 100 / 7 = 57. Area = 12.57.

Maximum of the numerator and denominator is 65535, although the **negative value calculation is not provided** but the result is able to show the negative value. For example, *-1+2* is not allowed in this function, but *1-2* is allowed and can show the value in negative which is *-1*.

Multiple arithmetic mix calculation. In this function able to calculate the mixed operation with correct priority, it means that the formula entered can include +,-,*,/ at the same time. For example, this function allowed enter *1+2-3+4/8*2+1* and calculate the correct result, when the denominator and numerator do not exceed the limit of 65535.

Bracket (parentheses) algorithm. Since including the priority of the operator, this function can use '(' and ')' to specify which part of the formula has the higher priority. For example, *1+((2-3)+(4/8*2+1))* is allowed and able to calculate the correct result, when the denominator and numerator do not exceed the limit of 65535.

Mix number and fraction algorithm. As the examples in above, all of them are whole number examples, it is only for easier explanation. This function is allowed the 3 types of fractions with whole numbers calculation. For example, *1+1,2,3*1,2-4,2* **(use " , " represent the / in the fraction)**, this is a combination of whole number, mixed fraction, proper fraction and improper fraction, and it is allowed when the denominator and numerator do not exceed the limit of 65535.

Simplify Fraction and decimal conversion. The result given by this function will include proper/improper fraction, mixed fraction and digits with 2 decimal places rounded.

Due to the time constraint the **limitation on the max value of denominator and numerator does not apply**. This is also the main constraint of this calculation, because this calculator provides a chance for the user to enter the whole formula as a string and different type of number. Therefore, too many possible combinations can occur, and a huge amount of testing needs to be included. So the user should ensure that the result of the denominator and numerator will not exceed 65535.

Extra information, if the calculation is something like *20-(x*x), x*x cannot be more than 32768,* because 20 minus something bigger than it is the result already stored as a signed number. The maximum value of the register will from 65535 decreasing to 32768.

This function provided all the basic calculations that help in calculating the statistical values. The calculation provided : ***Mode, Median, Mean, Largest Smallest value, range, variance, standard deviation, sample variance and sample standard deviation***. All of these are the basic elements for doing advanced statistical analysis and calculation.

This function will take all the numbers with 2 decimal places only. It means that this function will allow users enter 1.0847 but the system will only take 2 decimal places so only take 1.08. Therefore, this function might have the **error range between +-0.2**. But if all the digits are entered properly maximum 3 digit and maximum 2 decimal places **error range can reduce between +-0.1**. **Except the variance** will have **+-2 error range**, this is because differences of 0.01 will bring a big difference in square and square root. For example, *79.37²=6299.57* but *79.38²=6301.18* the difference is almost close to 2.

Moreover, to achieve the **square root algorithm**, this function is using the **newton raphson method** to find the nearest result, but due to the limitation of 16 bits system and time limitation. This function will not care about the decimal place during every round of calculation, to ensure the accuracy of result the times of execution is added.

Furthermore this function also includes the square algorithm. To achieve high accuracy this function will separate the number into digit and decimal (in source code represented by **RD=raw data** and **RDP=raw data point**). For example **80.12** will store as **80 and 12** to proceed the *(a+b)² = a²+b²+2ab* to get the square result.

In order to find the median this function also included the sorting method which is the common **selection sort**, using this technique is because that is the simplest way to do sorting and since the array size is considered small. In searching only apply the normal sequential search to find the value to arrange.

The main constraint of this calculation is on the total of each square number, it will need a more complex method to proceed with the square root, add, minus on DX:AX combination, since it is quite new for me, it will not able to solve and do testing within the estimate time of this assignment.

Screenshots for the system operation

Base Conversion & Calculation

Base Conversion function:
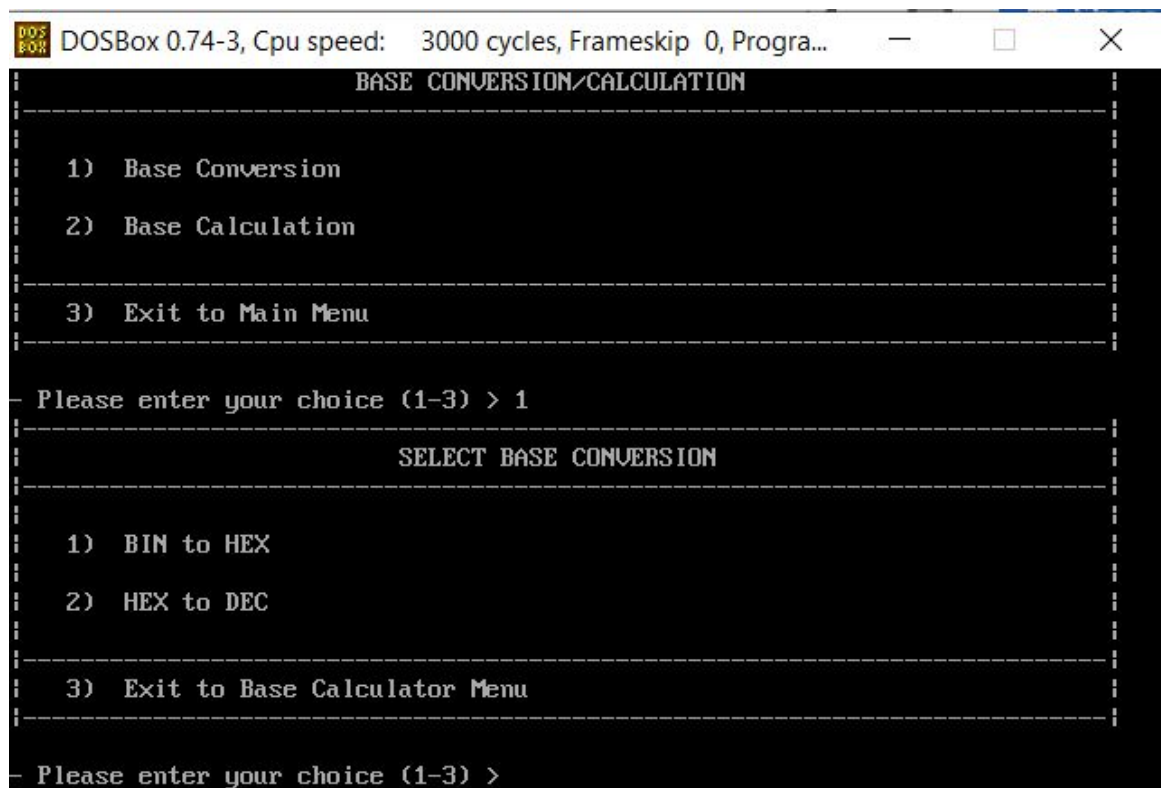
After selecting the base conversion function, the system will prompt the user to select the base conversion, or return to the base calculator menu. If invalid choice, user will be asked to input again.

If the user selects the BIN to HEX base conversion function, the system will prompt the user to input a 16-bit binary number. If invalid input, user will be asked to input again.

After inputting a valid binary number, the system will display the conversion result in hexadecimal (Refer conversion result to diagram 1.0). Then, the system will ask the user if there is anymore calculation. If yes, the user will input a binary number again to perform the conversion. If no, the user will be brought back to the main menu.
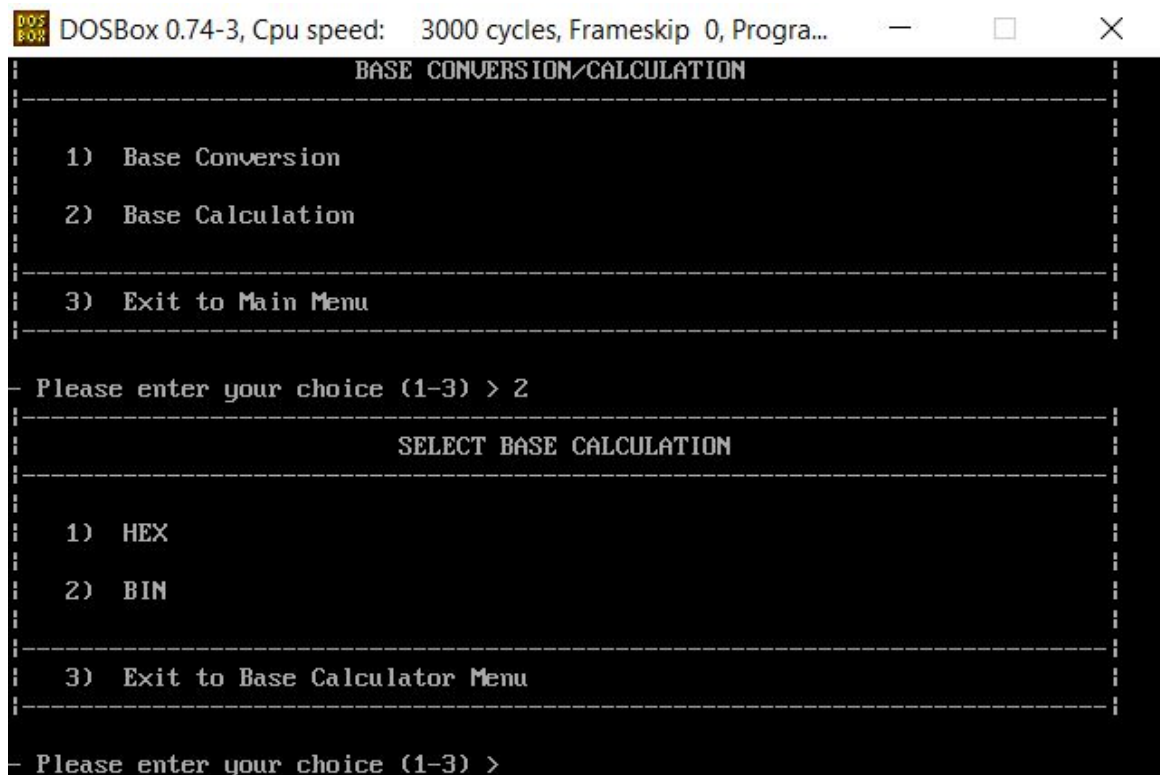
If the user selects the HEX to DEC base conversion function, the system will prompt the user to input a 16-bit hexadecimal number. If invalid input, user will be asked to input again.
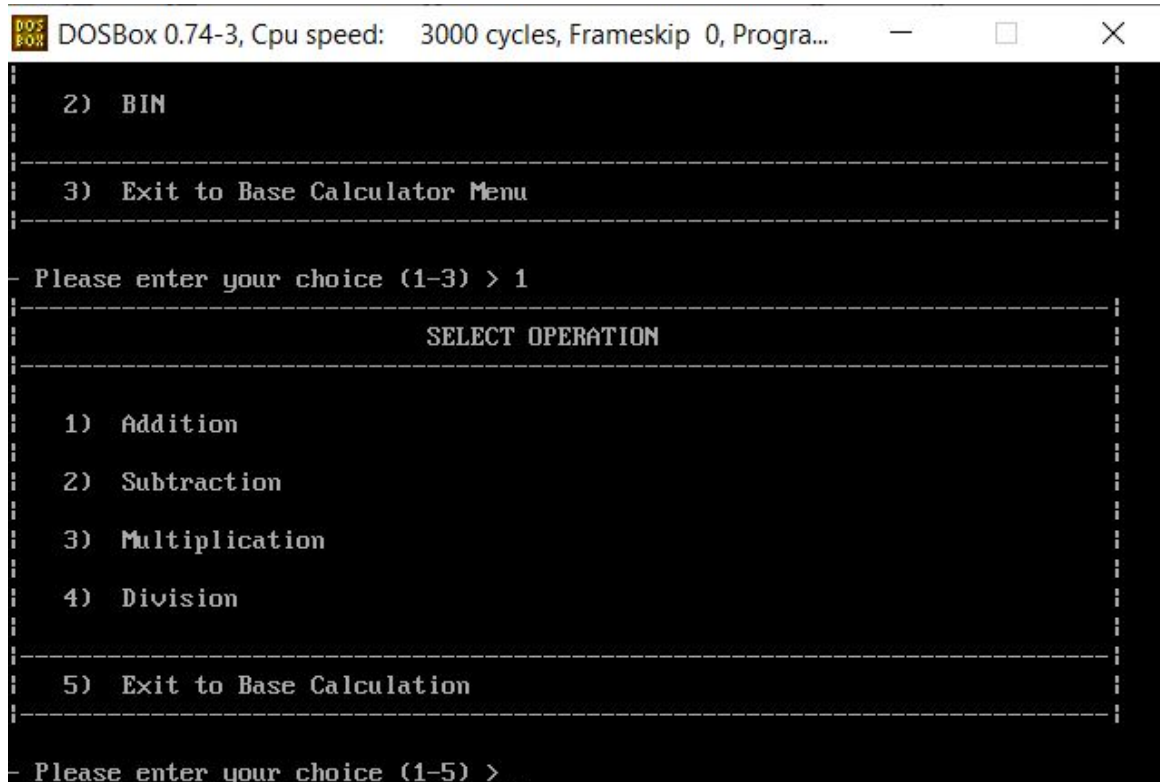
After inputting a valid hexadecimal number, the system will display the conversion result in decimal (Refer conversion result to diagram 1.1). Then, the system will ask the user if there is anymore calculation. If yes, the user will input a hexadecimal number again to perform the conversion. If no, the user will be brought back to the main menu.

Base Calculation function:

After selecting the base calculation function, the system will prompt the user to select the base, or return to the base calculator menu. If invalid choice, user will be asked to input again.

If the user selects HEX as base, the system will prompt the user to select the operation, or return to the base calculator menu. If invalid choice, user will be asked to input again.

If the user selects the addition function, the system will prompt the user to input two 16-bit hexadecimal operands. If invalid input, user will be asked to input again.

After inputting valid operands, the system will perform the addition operation and display the result (Refer calculation result to diagram 1.2). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the operands again to perform the addition operation. If no, the user will be brought back to the main menu.

If the user selects the subtraction function, the system will prompt the user to input two 16-bit hexadecimal operands. If invalid input, user will be asked to input again.

After inputting valid operands, the system will perform the subtraction operation and display the result (Refer calculation result to diagram 1.3). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the operands again to perform the subtraction operation. If no, the user will be brought back to the main menu.

If the user selects the multiplication function, the system will prompt the user to input two 8-bit hexadecimal operands. If invalid input, user will be asked to input again.

After inputting valid operands, the system will perform the multiplication operation and display the result (Refer calculation result to diagram 1.4). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the operands again to perform the multiplication operation. If no, the user will be brought back to the main menu.

If the user selects the division function, the system will prompt the user to input two 16-bit hexadecimal operands. If invalid input, user will be asked to input again.

After inputting valid operands, the system will perform the division operation and display the result (Refer calculation result to diagram 1.5). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the operands again to perform the division operation. If no, the user will be brought back to the main menu.

If the user selects BIN as base, the system will prompt the user to select the operation, or return to the base calculator menu. If invalid choice, user will be asked to input again.

If the user selects the addition function, the system will prompt the user to input two 16-bit binary operands. If invalid input, user will be asked to input again.

After inputting valid operands, the system will perform the addition operation and display the result (Refer calculation result to diagram 1.6). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the operands again to perform the addition operation. If no, the user will be brought back to the main menu.

If the user selects the subtraction function, the system will prompt the user to input two 16-bit binary operands. If invalid input, user will be asked to input again.

After inputting valid operands, the system will perform the subtraction operation and display the result (Refer calculation result to diagram 1.7). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the operands again to perform the subtraction operation. If no, the user will be brought back to the main menu.

If the user selects the multiplication function, the system will prompt the user to input two 8-bit binary operands. If invalid input, user will be asked to input again.

After inputting valid operands, the system will perform the multiplication operation and display the result (Refer calculation result to diagram 1.8). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the operands again to perform the multiplication operation. If no, the user will be brought back to the main menu.

If the user selects the multiplication function, the system will prompt the user to input two 16-bit binary operands. If invalid input, user will be asked to input again.

```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip  0, Progra...    —    □    ✕

;------------------------------------------------------------------------------;
|                                                                              |
|    1)   Addition                                                             |
|                                                                              |
|    2)   Subtraction                                                          |
|                                                                              |
|    3)   Multiplication                                                       |
|                                                                              |
|    4)   Division                                                             |
|                                                                              |
;------------------------------------------------------------------------------;
|    5)   Exit to Base Calculation                                             |
;------------------------------------------------------------------------------;

  Please enter your choice (1-5) > 4

  16-bit binary number (1)
  Ex: 1111 1000 0000 1010 > 1111111111111111

  16-bit binary number (2)
  Ex: 1111 1000 0000 1010 > 0000000000000011

  DIVISION Result :   0101 0101 0101 0101

  Anymore Calculation? (1=Yes, 0=No) > _
```

After inputting valid operands, the system will perform the division operation and display the result(Refer calculation result to diagram 1.9). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the operands again to perform the division operation. If no, the user will be brought back to the main menu.

Area/Volume Calculation

Area Calculation:

After selecting the area function, the system will prompt the user to select the area shape, or return to the base calculator menu. If invalid choice, user will be asked to input again.

If the user selects the rectangle area function, the system will prompt the user to input the height and width. If invalid input, user will be asked to input again.

After inputting valid height and width, the system will apply the formula, perform the area calculation and display the result (Refer calculation result to diagram 2.0). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the height and width again to perform the calculation. If no, the user will be brought back to the main menu.

If the user selects the triangle area function, the system will prompt the user to input the height and base. If invalid input, user will be asked to input again.

```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip 0, Progra...    —    □    ✕

 Please enter your choice (1-3) > 1
+-------------------------------------------------------------------+
|                      SELECT AREA CALCULATION                      |
+-------------------------------------------------------------------+
|                                                                   |
|   1)  Rectangle                                                   |
|                                                                   |
|   2)  Triangle                                                    |
|                                                                   |
|   3)  Circle                                                      |
|                                                                   |
+-------------------------------------------------------------------+
|   4)  Exit to Main Men                                            |
+-------------------------------------------------------------------+

 Please enter your choice (1-4) > 2

 Height (cm) (1-362) > 361

 Base    (cm) (1-362) > 361

 Area of TRIANGLE : 65160.50 cm^2

 Anymore Calculation? (1=Yes, 0=No) > _
```

After inputting valid height and base, the system will apply the formula, perform the area calculation and display the result (Refer calculation result to diagram 2.1). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the height and base again to perform the calculation. If no, the user will be brought back to the main menu.

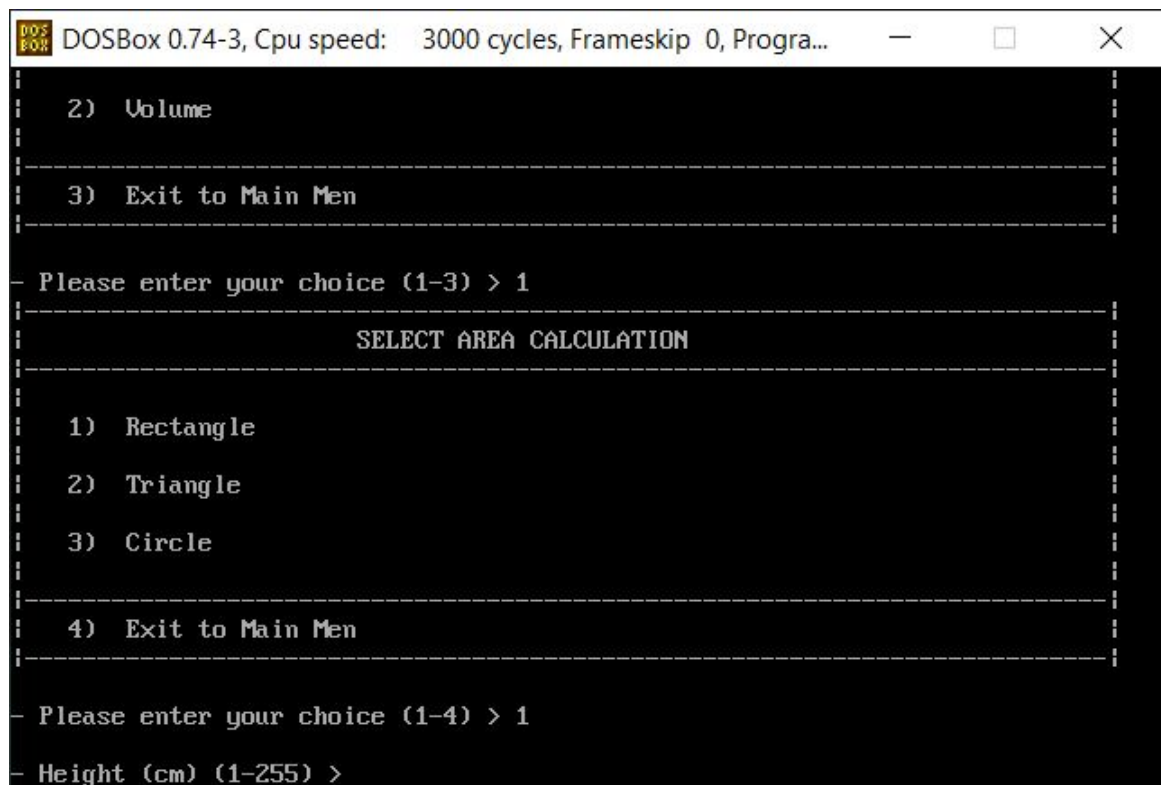```
DOSBox 0.74-3, Cpu speed: 3000 cycles, Frameskip 0, Progra...   —   □   ✕

| 2) Volume |
| |
+---+
| 3) Exit to Main Men |
+---+

 Please enter your choice (1-3) > 1
+---+
| SELECT AREA CALCULATION |
+---+
| |
| 1) Rectangle |
| |
| 2) Triangle |
| |
| 3) Circle |
| |
+---+
| 4) Exit to Main Men |
+---+

 Please enter your choice (1-4) > 3

 Radius (cm) (1-144) > _
```

If the user selects the circle area function, the system will prompt the user to input the radius. If invalid input, user will be asked to input again.
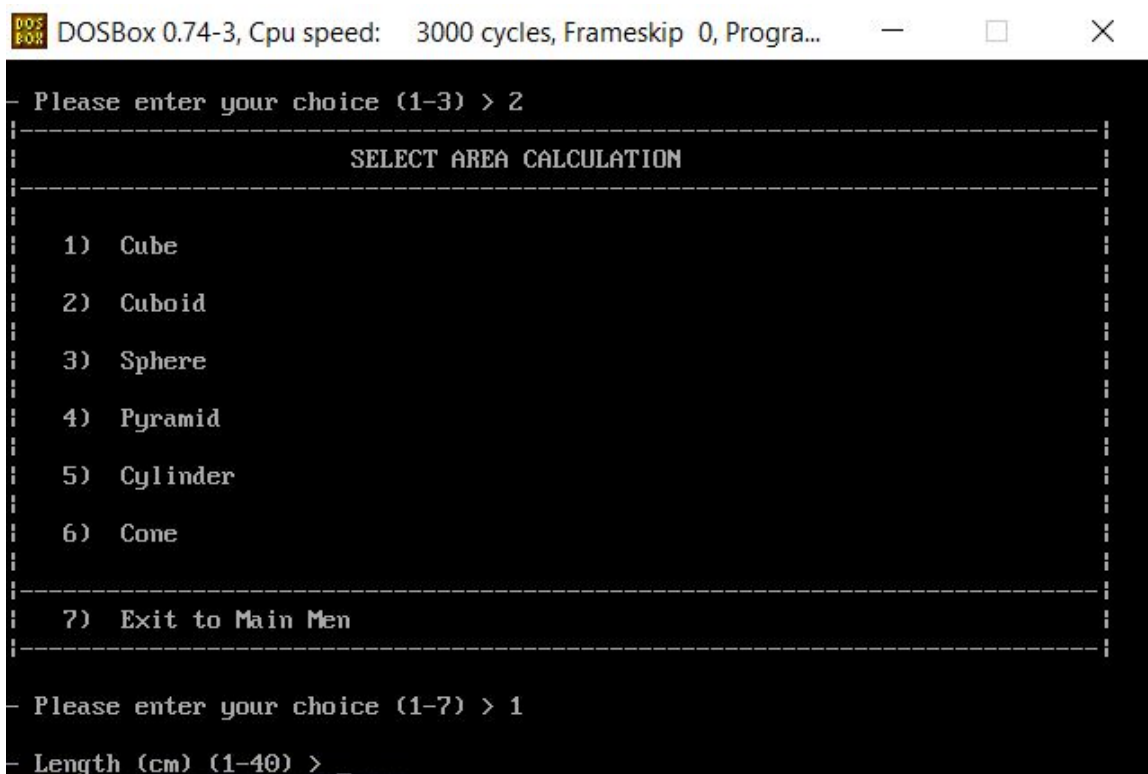
```
DOSBox 0.74-3, Cpu speed: 3000 cycles, Frameskip 0, Progra...   —   □   ×

  3) Exit to Main Men
¦--¦

- Please enter your choice (1-3) > 1
¦--¦
¦   SELECT AREA CALCULATION   ¦
¦--¦
¦   ¦
¦   1)   Rectangle   ¦
¦   ¦
¦   2)   Triangle   ¦
¦   ¦
¦   3)   Circle   ¦
¦   ¦
¦--¦
¦   4) Exit to Main Men   ¦
¦--¦

- Please enter your choice (1-4) > 3

- Radius (cm) (1-144) > 2

- Area of CIRCLE : 12.57 cm^2

- Anymore Calculation? (1=Yes, 0=No) >
```

After inputting valid radius, the system will apply the formula, perform the area calculation and display the result (Refer calculation result to diagram 2.2). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the radius again to perform the calculation. If no, the user will be brought back to the main menu.
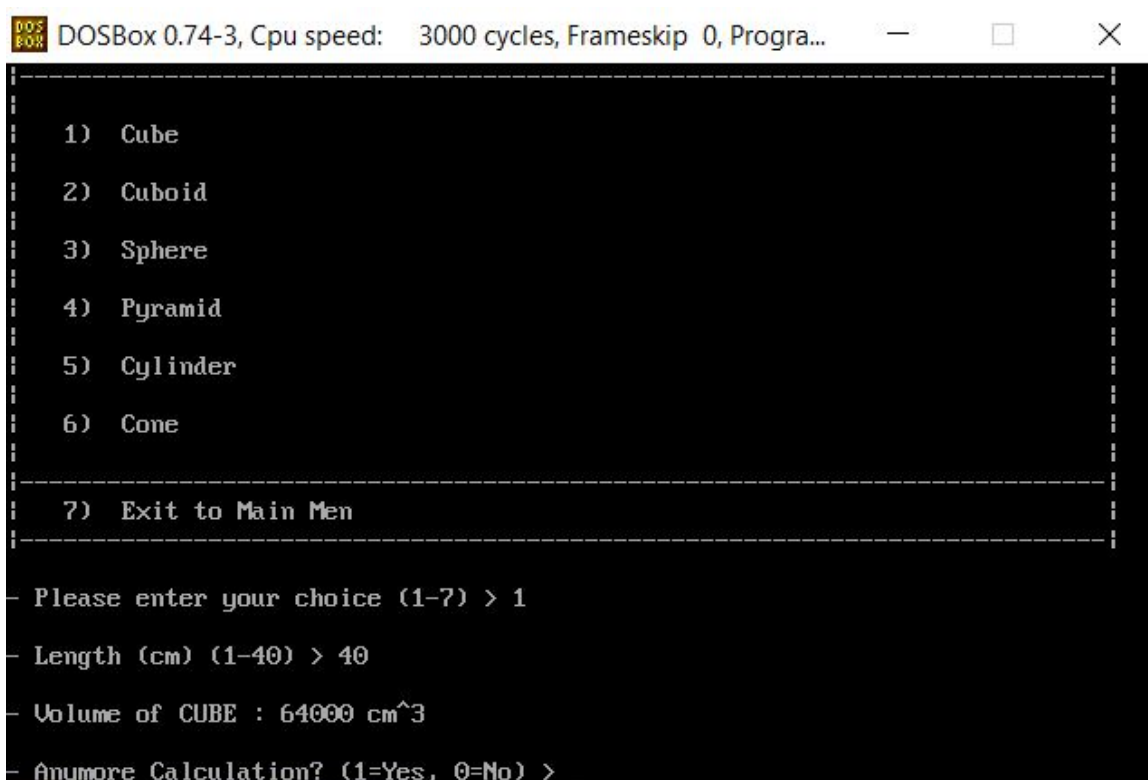
Volume Calculation:

```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip  0, Progra...   —   □   ×

  3)  Exit to Main Men
¦--------------------------------------------------------------------¦

- Please enter your choice (1-3) > 2
¦--------------------------------------------------------------------¦
¦                    SELECT AREA CALCULATION                         ¦
¦--------------------------------------------------------------------¦
¦                                                                    ¦
¦   1)  Cube                                                         ¦
¦                                                                    ¦
¦   2)  Cuboid                                                       ¦
¦                                                                    ¦
¦   3)  Sphere                                                       ¦
¦                                                                    ¦
¦   4)  Pyramid                                                      ¦
¦                                                                    ¦
¦   5)  Cylinder                                                     ¦
¦                                                                    ¦
¦   6)  Cone                                                         ¦
¦                                                                    ¦
¦--------------------------------------------------------------------¦
¦   7)  Exit to Main Men                                             ¦
¦--------------------------------------------------------------------¦

- Please enter your choice (1-7) >
```

After selecting the volume function, the system will prompt the user to select the volume shape, or return to the base calculator menu. If invalid choice, user will be asked to input again.

```
  Please enter your choice (1-3) > 2
|------------------------------------------------------------|
|                   SELECT AREA CALCULATION                  |
|------------------------------------------------------------|
|                                                            |
|   1)  Cube                                                 |
|                                                            |
|   2)  Cuboid                                               |
|                                                            |
|   3)  Sphere                                               |
|                                                            |
|   4)  Pyramid                                              |
|                                                            |
|   5)  Cylinder                                             |
|                                                            |
|   6)  Cone                                                 |
|                                                            |
|------------------------------------------------------------|
|   7)  Exit to Main Men                                     |
|------------------------------------------------------------|

  Please enter your choice (1-7) > 1

  Length (cm) (1-40) > _
```

If the user selects the cube volume function, the system will prompt the user to input the length. If invalid input, user will be asked to input again.


```
|------------------------------------------------------------|
|                                                            |
|   1)  Cube                                                 |
|                                                            |
|   2)  Cuboid                                               |
|                                                            |
|   3)  Sphere                                               |
|                                                            |
|   4)  Pyramid                                              |
|                                                            |
|   5)  Cylinder                                             |
|                                                            |
|   6)  Cone                                                 |
|                                                            |
|------------------------------------------------------------|
|   7)  Exit to Main Men                                     |
|------------------------------------------------------------|

  Please enter your choice (1-7) > 1

  Length (cm) (1-40) > 40

  Volume of CUBE : 64000 cm^3

  Anymore Calculation? (1=Yes, 0=No) > _
```

After inputting valid length, the system will apply the formula, perform the volume calculation and display the result (Refer calculation result to diagram 2.3). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the length again to perform the calculation. If no, the user will be brought back to the main menu.

If the user selects the cuboid volume function, the system will prompt the user to input the length, height and width. If invalid input, user will be asked to input again.

After inputting valid length, height and width the system will apply the formula, perform the volume calculation and display the result (Refer calculation result to diagram 2.3). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the length, height and width again to perform the calculation. If no, the user will be brought back to the main menu.

```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip  0, Progra...    —    □    ×

Please enter your choice (1-3) > 2
|------------------------------------------------------------------------------|
                           SELECT AREA CALCULATION
|------------------------------------------------------------------------------|

   1)   Cube

   2)   Cuboid

   3)   Sphere

   4)   Pyramid

   5)   Cylinder

   6)   Cone

|------------------------------------------------------------------------------|
   7)   Exit to Main Menu
|------------------------------------------------------------------------------|

Please enter your choice (1-7) > 3

Radius (cm) (1-14) > _
```

If the user selects the sphere volume function, the system will prompt the user to input the radius. If invalid input, user will be asked to input again.

```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip  0, Progra...    —    □    ×

|------------------------------------------------------------------------------|
   1)   Cube

   2)   Cuboid

   3)   Sphere

   4)   Pyramid

   5)   Cylinder

   6)   Cone

|------------------------------------------------------------------------------|
   7)   Exit to Main Menu
|------------------------------------------------------------------------------|

Please enter your choice (1-7) > 3

Radius (cm) (1-14) > 2

Volume of SPHERE : 33.52 cm^3

Anymore Calculation? (1=Yes, 0=No) > _
```

After inputting a valid radius the system will apply the formula, perform the volume calculation and display the result (Refer calculation result to diagram 2.4). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the radius again to perform the calculation. If no, the user will be brought back to the main menu.

If the user selects the pyramid volume function, the system will prompt the user to input the length, height and width. If invalid input, user will be asked to input again.

After inputting valid length, height and width the system will apply the formula, perform the volume calculation and display the result (Refer calculation result to diagram 2.5). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the length, height and width again to perform the calculation. If no, the user will be brought back to the main menu.

```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip  0, Progra...    —    ☐    ✕

- Please enter your choice (1-3) > 2
;-----------------------------------------------------------------;
¦                      SELECT AREA CALCULATION                    ¦
;-----------------------------------------------------------------;
¦                                                                 ¦
¦   1)  Cube                                                      ¦
¦                                                                 ¦
¦   2)  Cuboid                                                    ¦
¦                                                                 ¦
¦   3)  Sphere                                                    ¦
¦                                                                 ¦
¦   4)  Pyramid                                                   ¦
¦                                                                 ¦
¦   5)  Cylinder                                                  ¦
¦                                                                 ¦
¦   6)  Cone                                                      ¦
¦                                                                 ¦
;-----------------------------------------------------------------;
¦   7)  Exit to Main Men                                          ¦
;-----------------------------------------------------------------;

- Please enter your choice (1-7) > 5

- Radius (cm) (1-27) >
```

If the user selects the cylinder volume function, the system will prompt the user to input the radius and height. If invalid input, user will be asked to input again.

```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip  0, Progra...    —    ☐    ✕

¦   1)  Cube                                                      ¦
¦                                                                 ¦
¦   2)  Cuboid                                                    ¦
¦                                                                 ¦
¦   3)  Sphere                                                    ¦
¦                                                                 ¦
¦   4)  Pyramid                                                   ¦
¦                                                                 ¦
¦   5)  Cylinder                                                  ¦
¦                                                                 ¦
¦   6)  Cone                                                      ¦
¦                                                                 ¦
;-----------------------------------------------------------------;
¦   7)  Exit to Main Men                                          ¦
;-----------------------------------------------------------------;

- Please enter your choice (1-7) > 5

- Radius (cm) (1-27) > 27

- Height (cm) (1-27) > 27

- Volume of CYLINDER : 61860.85 cm^3

- Anymore Calculation? (1=Yes, 0=No) >
```
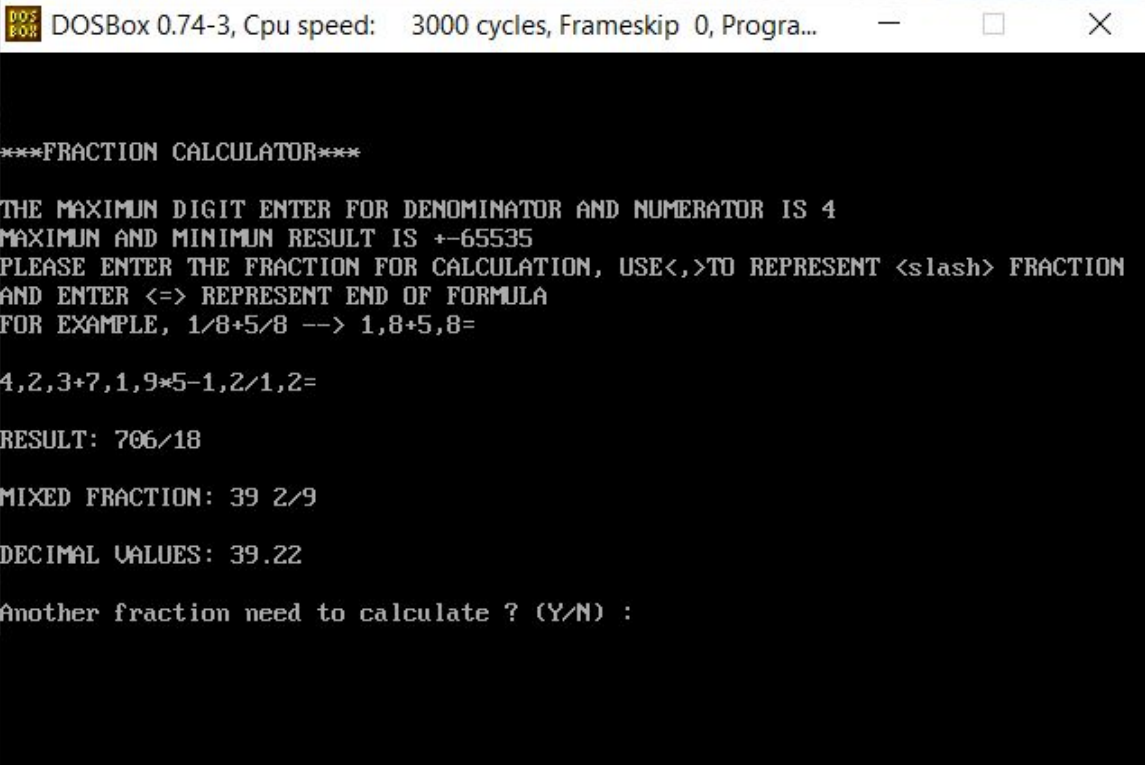
After inputting valid radius and height the system will apply the formula, perform the volume calculation and display the result (Refer calculation result to diagram 2.6). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the radius and height again to perform the calculation. If no, the user will be brought back to the main menu.

If the user selects the cone volume function, the system will prompt the user to input the radius and height. If invalid input, user will be asked to input again.

After inputting valid radius and height the system will apply the formula, perform the volume calculation and display the result(Refer calculation result to diagram 2.7). Then, the system will ask the user if there is anymore calculation. If yes, the user will input the radius and height again to perform the calculation. If no, the user will be brought back to the main menu.

Fraction Calculation

Example use $4\frac{2}{3} + 7\frac{1}{9} * 5 - \frac{1}{2} \div \frac{1}{2} = 39\frac{2}{9}$ (answer from calculator fx-570ms)

Combination of mixed, informal, formal fraction and also the whole number

Example use (100+50)/10*(1+2)-65=-20 (answer from calculator fx-570ms)

Priority algorithm to do the formula calculation

Fraction Calculation- Error presentation 1

Example use ***20-(180*180)=-32380*** (answer from calculator fx-570ms)
As the screenshot shows, the result is **correct**. Because the 180*180=32400 lower than 2^{15} =32768.
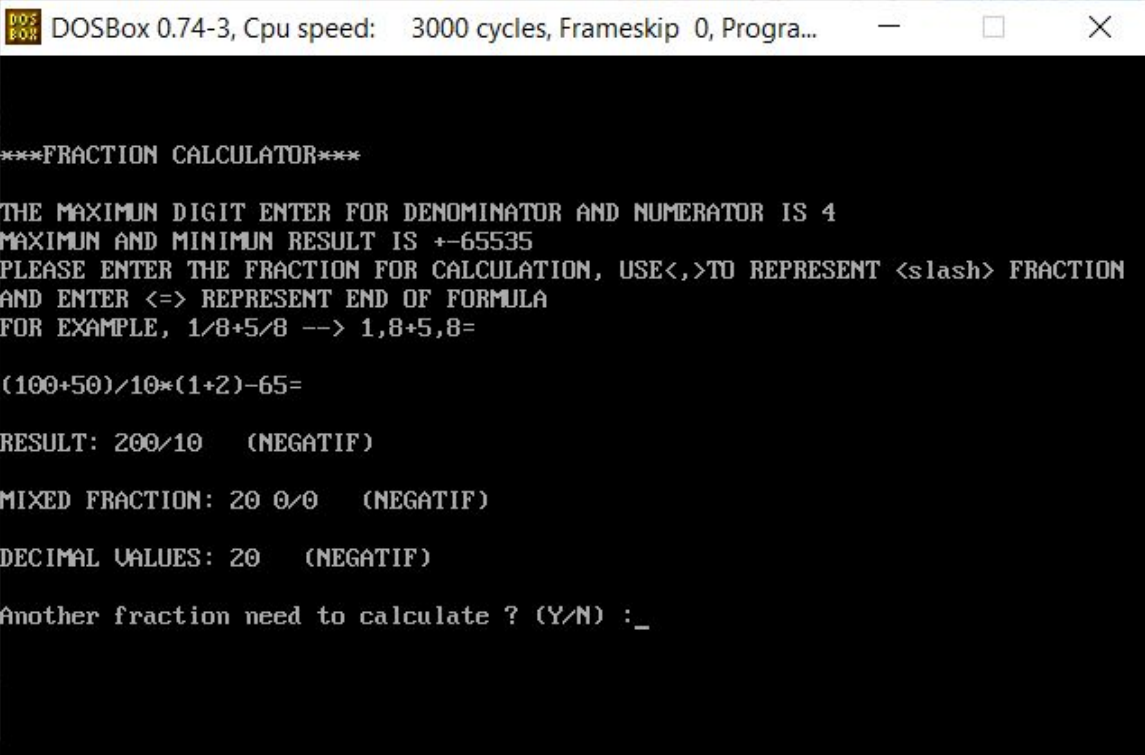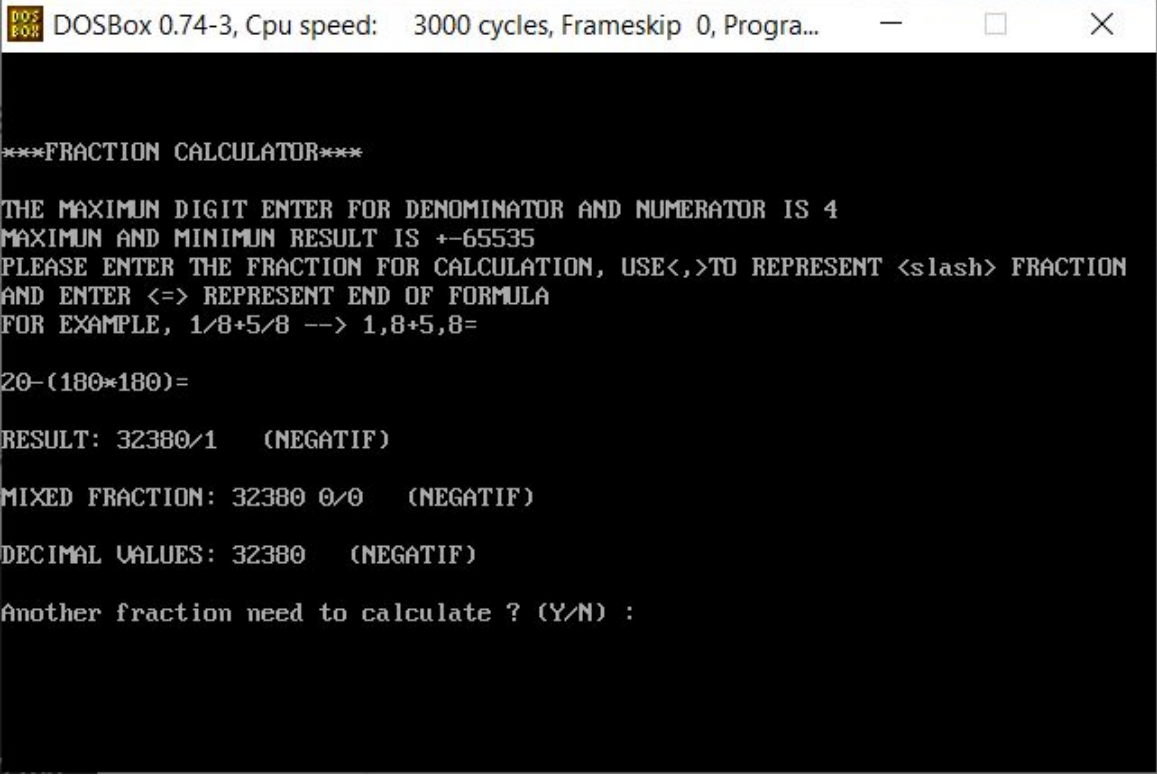

```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip  0, Progra...    —    □    ×



***FRACTION CALCULATOR***

THE MAXIMUN DIGIT ENTER FOR DENOMINATOR AND NUMERATOR IS 4
MAXIMUN AND MINIMUN RESULT IS +-65535
PLEASE ENTER THE FRACTION FOR CALCULATION, USE<,>TO REPRESENT <slash> FRACTION
AND ENTER <=> REPRESENT END OF FORMULA
FOR EXAMPLE, 1/8+5/8 --> 1,8+5,8=

20-(180*180)=

RESULT: 32380/1    (NEGATIF)

MIXED FRACTION: 32380 0/0    (NEGATIF)

DECIMAL VALUES: 32380    (NEGATIF)

Another fraction need to calculate ? (Y/N) :
```
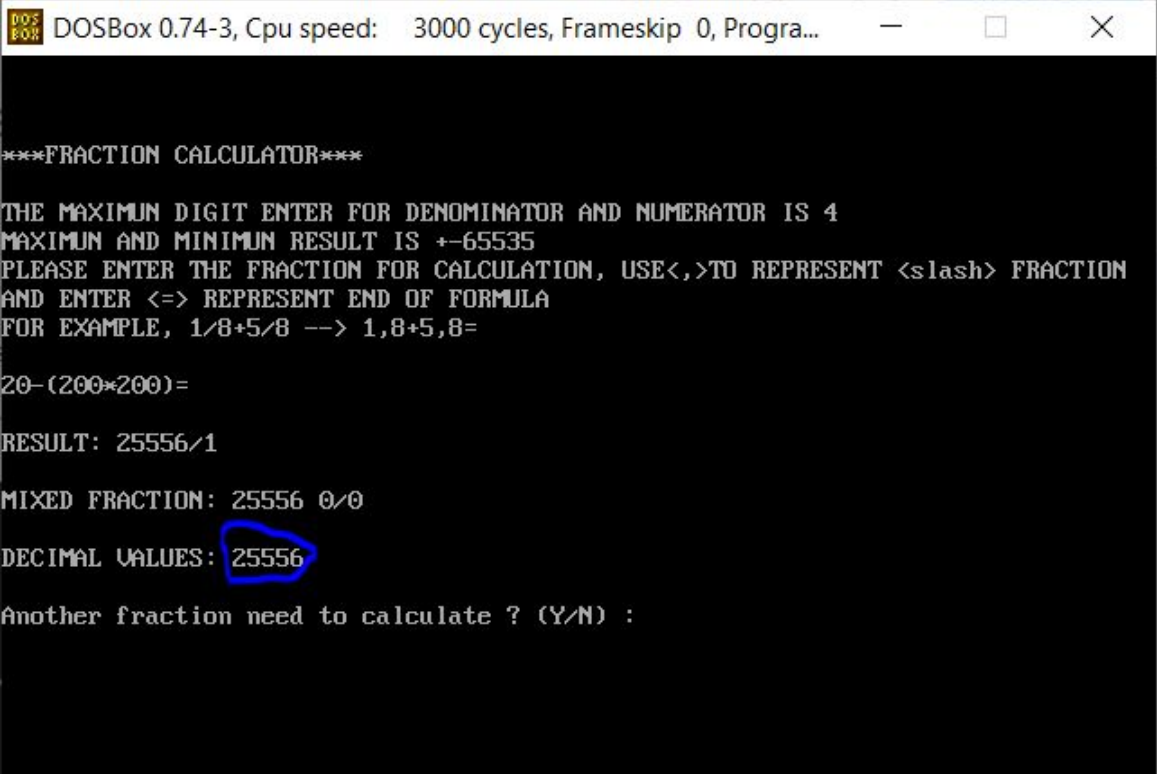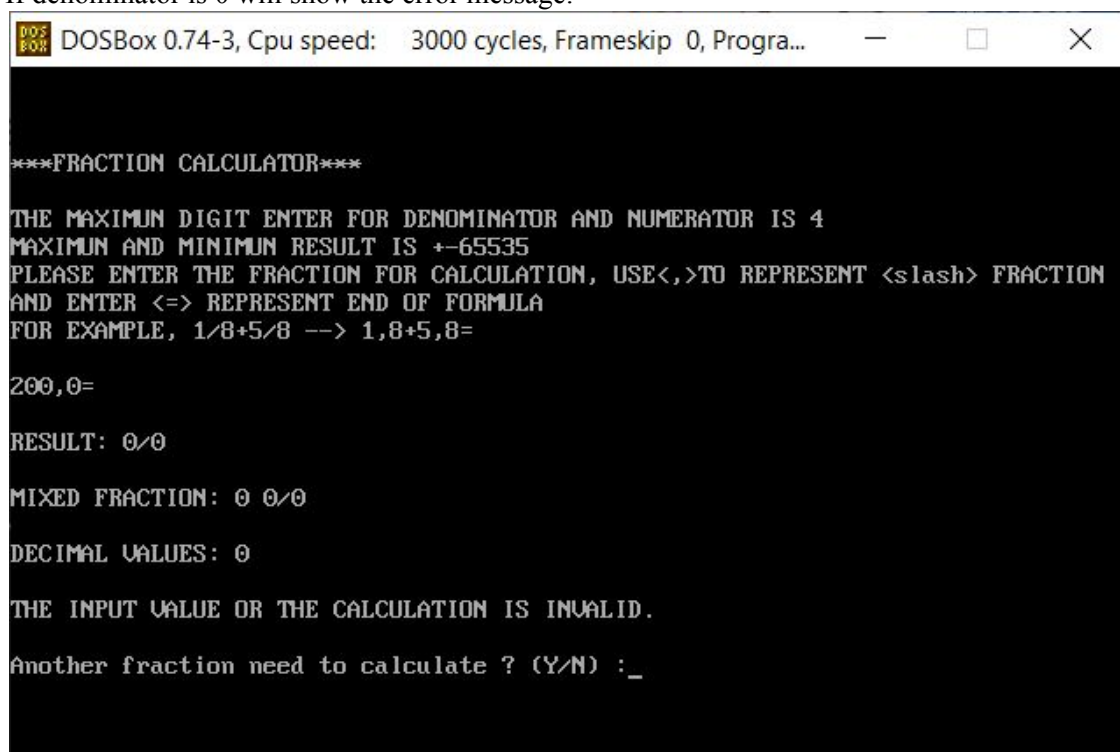
Example use ***20-(200*200)=-39980*** (answer from calculator fx-570ms)
As the screenshot shows, the result is **incorrect**. Because the 200*200=40000 higher than signed value limitation which is 2^{15} =32768 (actual is 32767 include 0). The error message cannot be shown because the overflow sign used to identify the sign of result.


```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip  0, Progra...    —    □    ×



***FRACTION CALCULATOR***

THE MAXIMUN DIGIT ENTER FOR DENOMINATOR AND NUMERATOR IS 4
MAXIMUN AND MINIMUN RESULT IS +-65535
PLEASE ENTER THE FRACTION FOR CALCULATION, USE<,>TO REPRESENT <slash> FRACTION
AND ENTER <=> REPRESENT END OF FORMULA
FOR EXAMPLE, 1/8+5/8 --> 1,8+5,8=

20-(200*200)=

RESULT: 25556/1

MIXED FRACTION: 25556 0/0

DECIMAL VALUES: 25556

Another fraction need to calculate ? (Y/N) :
```
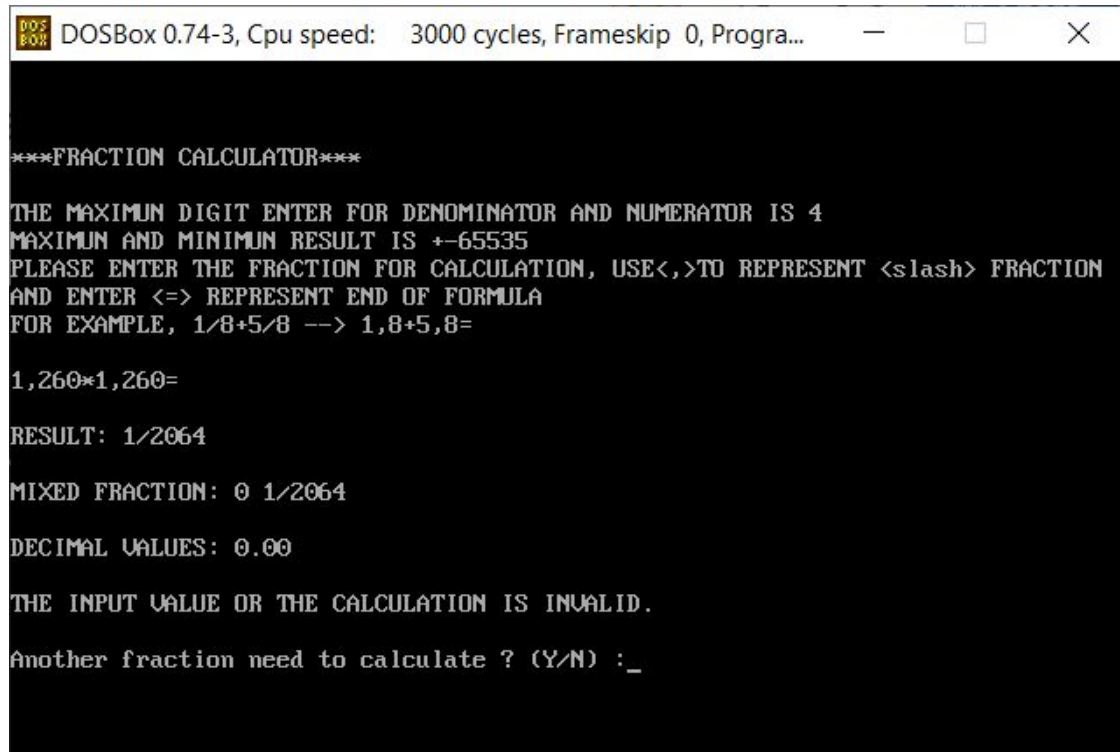
Fraction Calculation- Error presentation 2

Example use $\frac{1}{260} * \frac{1}{260} = \frac{1}{67600}$ (answer from calculator fx-570ms)

As the screenshot shows, the result is **incorrect**. Because the 260*260=67600 higher than the signed value limitation which is 2^{16} =65536 (actual is 65535 include 0). Therefore the error message shown.

Fraction Calculation- Error presentation 3

If denominator is 0 will show the error message.

Statistic calculation

Example use: **100.90, 200, 200.00, 100.80, 150.20, 99.998, 160, 180, 120, 110.75 (10 raw data)**
The total of square of this example is over 65535

*If you need to check the result, the reference section can find the **statistic calculator**, but the calculator will take 200 and 200.00 as different data. Therefore mode will be different between this function and the statistics calculator

```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip  0, Progra...    —    □    ✕
NUMBERS YOU ENTERED:
100.90 200.00 200.00 100.80 150.20 99.99 160.00 180.00 120.00 110.75

ASCENDING ORDER OF NUMBERS YOU ENTERED:
99.99 100.80 100.90 110.75 120.00 150.20 160.00 180.00 200.00 200.00

COUNT: 10
MODE: 200.00
OCCUR TIMES: 2
MEDIAN: 135.10
AVERANGE: 142.26
LARGEST: 200.00    SMALLEST: 99.99
RANGE (LARGEST-SMALLEST): 100.01
SUM OF THE RAW DATA: 1422.64

THE TOTAL OF SQUARE VALUE IS OVER LIMIT,
SO WILL NOT CALCULATE THE FOLLOWING TERM

TOTAL OF EACH SQUARE: 0.00
VARIANCE: 0.00
STANDARD DEVIASION: 0.00
SAMPLE VARIANCE: 0.00
SAMPLE STANDARD DEVIASION: 0.00

Continue calculate another set of Data ? (Y/N) :
```

Count	10
Sum	1422.648
Mean (Average)	142.2648
Median	135.1
Mode	All values appeared just once.
Largest	200
Smallest	99.998
Range	100.002
Geometric Mean	137.05631173029
Standard Deviation	38.953715244634
Variance	1517.39193136
Sample Standard Deviation	41.060821166222
Sample Variance	1685.9910348444

Sorted data: 99.998, 100.80, 100.90, 110.75, 120, 150.20, 160, 180, 200, 200.00

As mentioned the value will only take 2 decimals, so **99.998** only takes **99.99**. Because this system will only consider 2 decimal points if user input more just ignore and without any carry operation. Therefore, that will have a +-0.1 error range of result.
Moreover, the total square for each data over 65535 will not do the calculation for standard deviation and variance.

Example use: **95.75, 90.5, 80.5, 80.25, 39, 55, 60, 69, 75, 70** (10 raw data -exam result)

```
DOSBox 0.74-3, Cpu speed:    3000 cycles, Frameskip  0, Progra...    —    □    ✕
PLEASE ENTER THE RAW DATA, EX:18.50
IF NO MORE DATA ENTER ANY CHARACTER TO STOP -> DATA : 95.75

NUMBERS YOU ENTERED:
39.00 55.00 60.00 69.00 70.00 75.00 80.25 80.50 90.50 95.75

ASCENDING ORDER OF NUMBERS YOU ENTERED:
39.00 55.00 60.00 69.00 70.00 75.00 80.25 80.50 90.50 95.75

COUNT: 10

MODE:   NO MODE ALL OCCUR TIMES IS SAME
OCCUR TIMES: 1
MEDIAN: 72.50
AVERANGE: 71.50
LARGEST: 95.75    SMALLEST: 39.00
RANGE (LARGEST-SMALLEST): 56.75
SUM OF THE RAW DATA: 715.00
TOTAL OF EACH SQUARE: 53710.62
VARIANCE: 258.81
STANDARD DEVIASION: 16.08
SAMPLE VARIANCE: 287.56
SAMPLE STANDARD DEVIASION: 16.95

Continue calculate another set of Data ? (Y/N) : _
```

Count	10
Sum	715
Mean (Average)	71.5
Median	72.5
Mode	All values appeared just once.
Largest	95.75
Smallest	39
Range	56.75
Geometric Mean	69.448284515659
Standard Deviation	16.087650543196
Variance	258.8125
Sample Standard Deviation	16.957872639115
Sample Variance	287.56944444444

Sorted data: 39, 55, 60, 69, 70, 75, 80.25, 80.5, 90.5, 95.75

Example use: **8, 11, 5, 12, 8** (Simple statistic question find sample variance)

```
DOSBox 0.74-3, Cpu speed:   3000 cycles, Frameskip  0, Progra...    —    □    ✕

YOUR INPUT SHOULD WITHIN 3 DIGIT AND 2 DECIMAL
PLEASE ENTER THE RAW DATA, EX:18.50
IF NO MORE DATA ENTER ANY CHARACTER TO STOP -> DATA : N

NUMBERS YOU ENTERED:
8.00 11.00 5.00 12.00 8.00

ASCENDING ORDER OF NUMBERS YOU ENTERED:
5.00 8.00 8.00 11.00 12.00

COUNT: 05
MODE: 8.00
OCCUR TIMES: 2
MEDIAN: 8.00
AVERANGE: 8.80
LARGEST: 12.00    SMALLEST: 5.00
RANGE (LARGEST-SMALLEST): 7.00
SUM OF THE RAW DATA: 44.00
TOTAL OF EACH SQUARE: 418.00
VARIANCE: 6.16
STANDARD DEVIASION: 2.48
SAMPLE VARIANCE: 7.70
SAMPLE STANDARD DEVIASION: 2.77

Continue calculate another set of Data ? (Y/N) :
```

Population variance, $\sigma^2 = 3.41^2 = 11.6$

Example
During a particular summer month, the number of central air-conditioning units sold by a random (sample) of 5 salespersons from a heating and air-conditioning firm were as follows:

$$8, \quad 11, \quad 5, \quad 12, \quad 8$$

Find the sample standard deviation and the sample variance.

Solution
$n = 5$
$\sum x = 8 + 11 + 5 + 12 + 8 = 44$
$\sum x^2 = 8^2 + 11^2 + 5^2 + 12^2 + 8^2 = 418$
Sample standard deviation,

$$s = \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}} = \sqrt{\frac{418 - \frac{(44)^2}{5}}{5-1}} = \sqrt{7.7} = 2.77 \text{ units}$$

他们之间相距 2.77 (销售量)

Variance
$s^2 = 7.7$ or $(2.77)^2 = 7.7 \text{ unit}^2$

24

42

Conclusion / future improvement   TEO WEN ZHI

In conclusion, this assignment provided me a better understanding of assembly and gave me a chance to apply other techniques, since there are less chances to use assembly as the main development language in my daily life. Therefore, this assignment included the different knowledge I learned from different areas, such as data structure programming for sorting algorithms and computer system architecture to achieve a higher standard or better quality of project.

Due to the time and platform limitations, actually most of the things are not fully implemented into the system. For example, improve the accuracy of Newton's method in square root and also the String calculation which can overcome the limitations of 65535. However, in this system all the things are prepared for future improvement that is the reason why most of the value is stored with double words(16 bits) instead of only one word(8 bits), and also the reason for making all the functions as module by module.

For the future improvement, I would like to discover how the assembly can communicate with hardware to improve my assembly and computer operation knowledge. Moreover, the area of 80386 can provide a larger register, also a way for easier development to a more complex and powerful system.

Conclusion / future improvement   **WONG WINNIE**

        As a conclusion, I have learnt a lot from this Introduction to Computer Systems assignment. I have applied previous knowledge of computer systems architecture and programming to develop this programme. By using the 8086 assembly language, I have enhanced my skills in problem solving, debugging, critical thinking and logical thinking. These skills will assist me in becoming a better programmer and help me understand programming further to develop more quality and efficient systems.

        For future improvements, I would like to achieve a better standard of a system which allows more complex calculations, wider range of input and as few limitations possible. I would like to venture into more complex and challenging aspects of 8086 assembly language in order to create different types of programs.

Task allocation for each member

Main menu development and design	Wong Winnie
Base Conversion & Calculation	Wong Winnie
Area/Volume Calculation	Wong Winnie
Fraction Calculation	Teo Wen Zhi
Statistic calculation	Teo Wen Zhi
Combine and Testing	Teo Wen Zhi & Wong Winnie

Reference section

Calculator.net, 2020, Statistics Calculator. [online] Calculator.net. Available at: <https://www.calculator.net/statistics-calculator.html>

GitHub 2020, wenzhi0209/Banking-System-Csa-Assembly, viewed 6 November 2020, <https://github.com/wenzhi0209/Banking-System-Csa-Assembly>

Rapidtables.com. 2020. Base Calculator | Math Calculators. [online] Available at: <https://www.rapidtables.com/calc/math/base-calculator.html>

calculator, a., 2020. Area Calculator. [online] Calculator.net. Available at: <https://www.calculator.net/area-calculator.html>

calculator, v., 2020. Volume Calculator. [online] Calculator.net. Available at: <https://www.calculator.net/volume-calculator.html>

Appendices
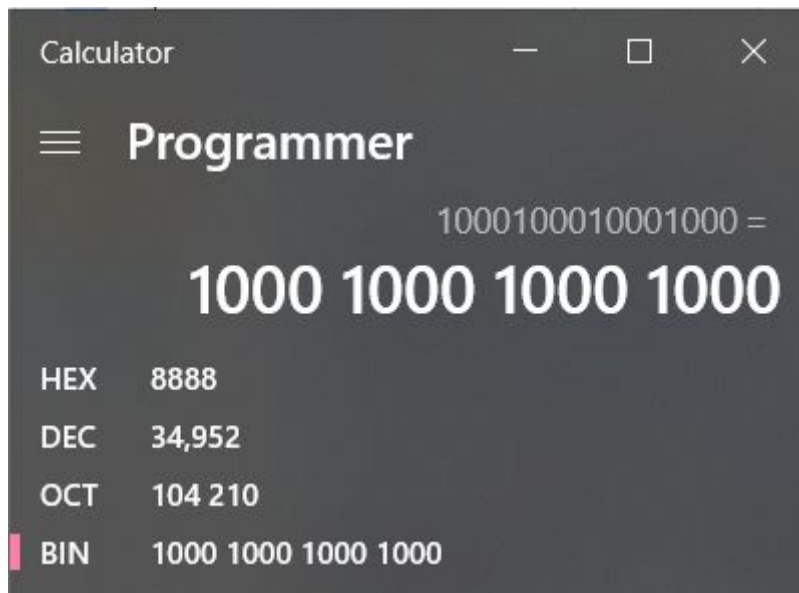
Diagram 1.0
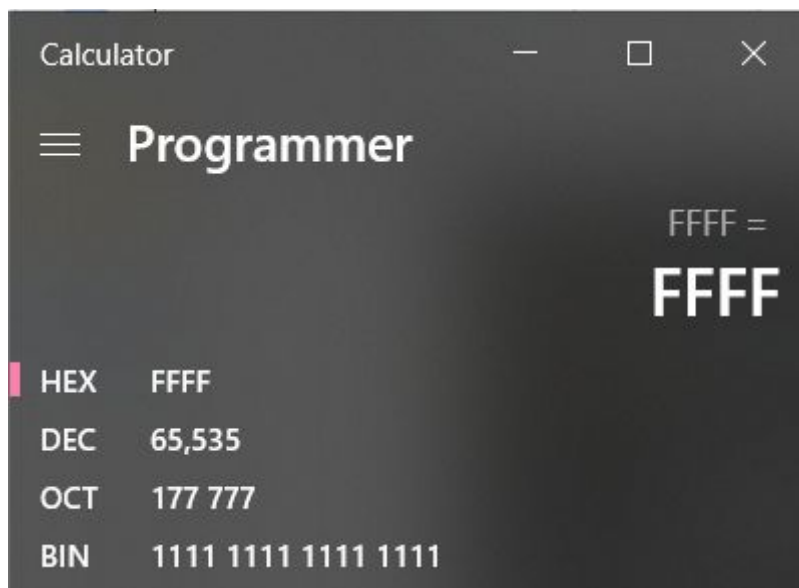
Diagram 1.1
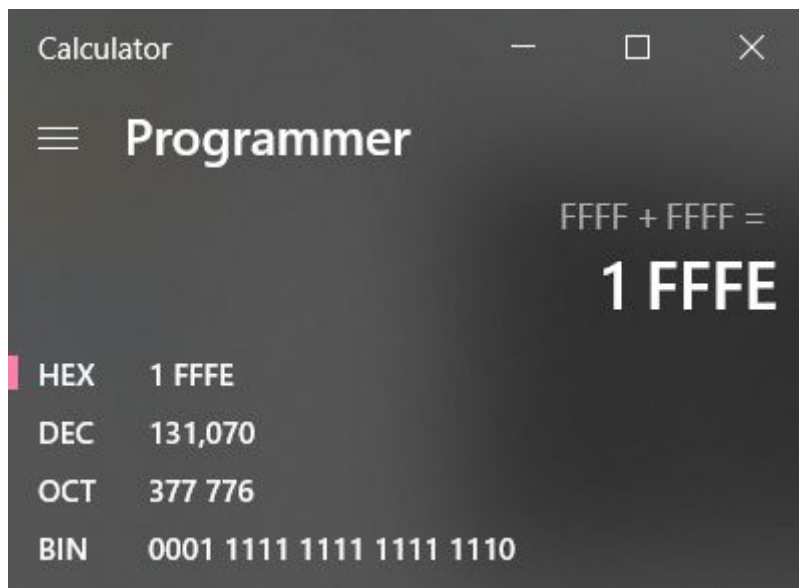
Diagram 1.2
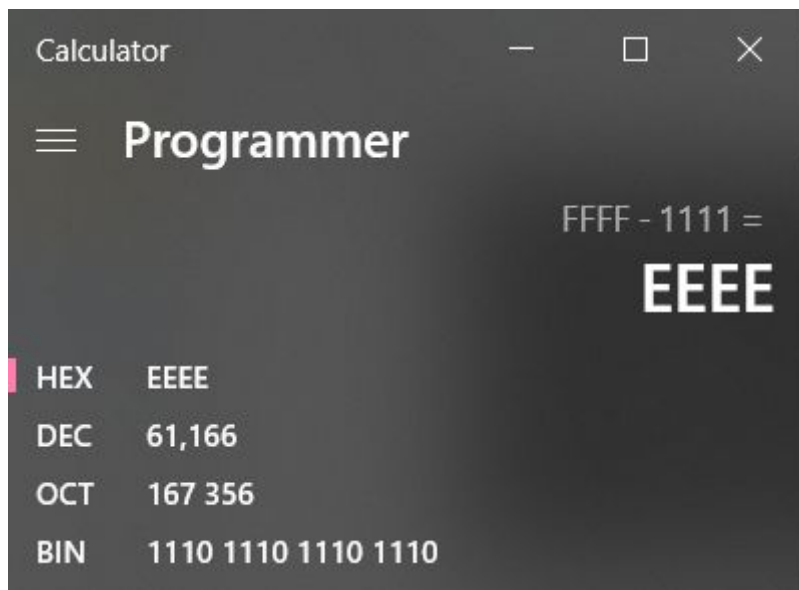
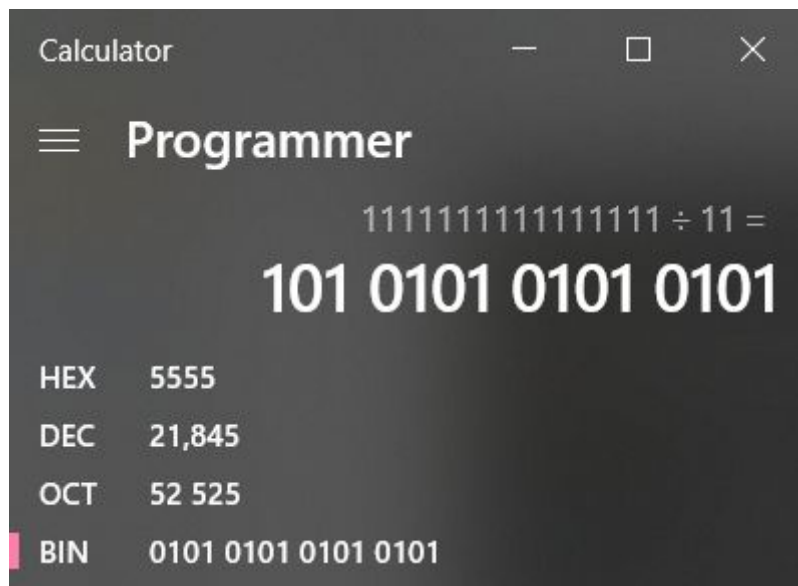Diagram 1.3

Diagram 1.4

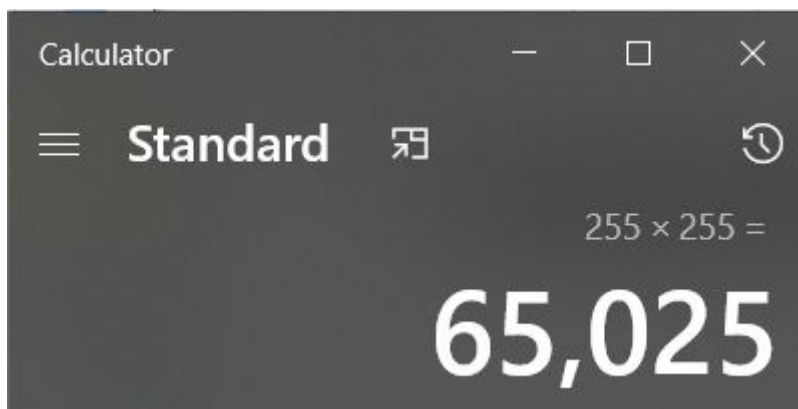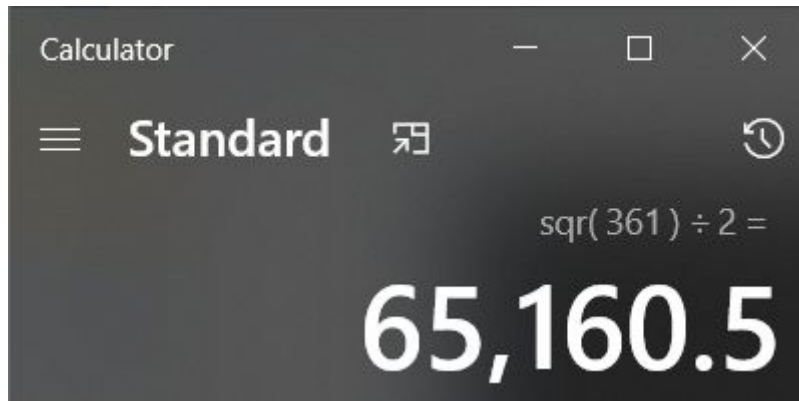Diagram 1.5
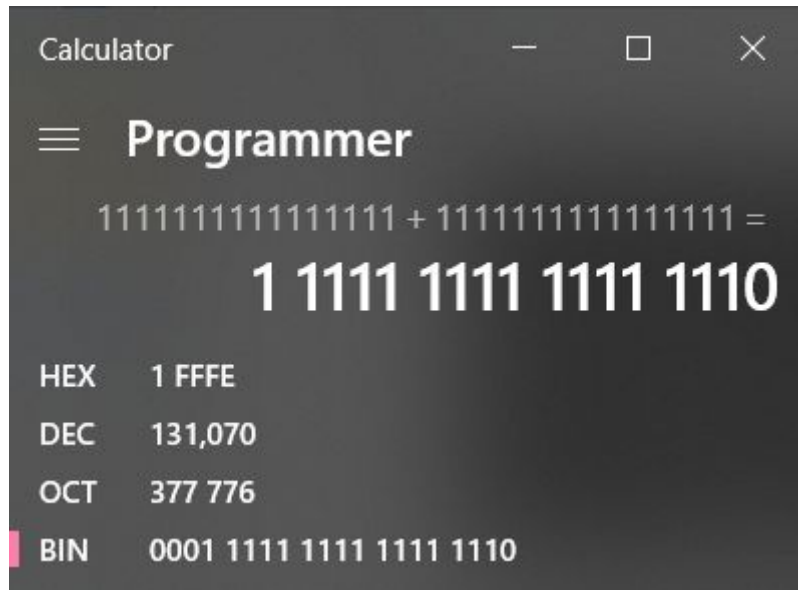
Diagram 1.6
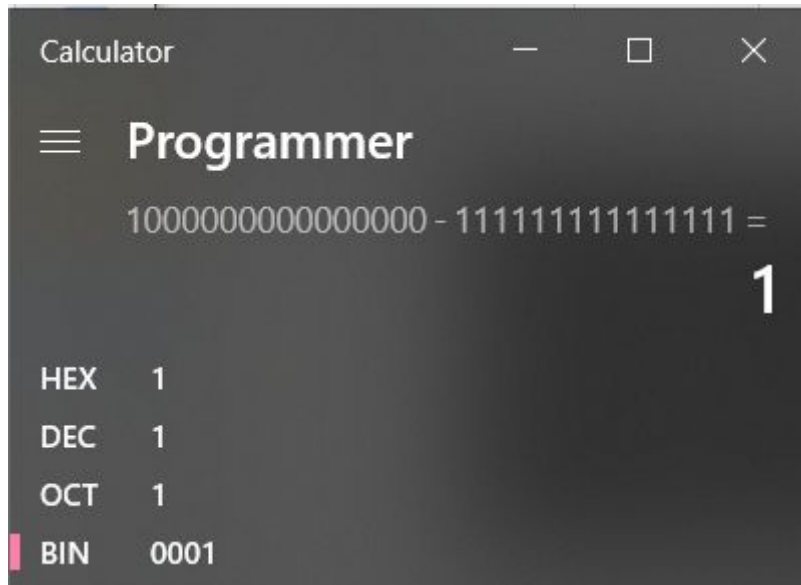
Diagram 1.7
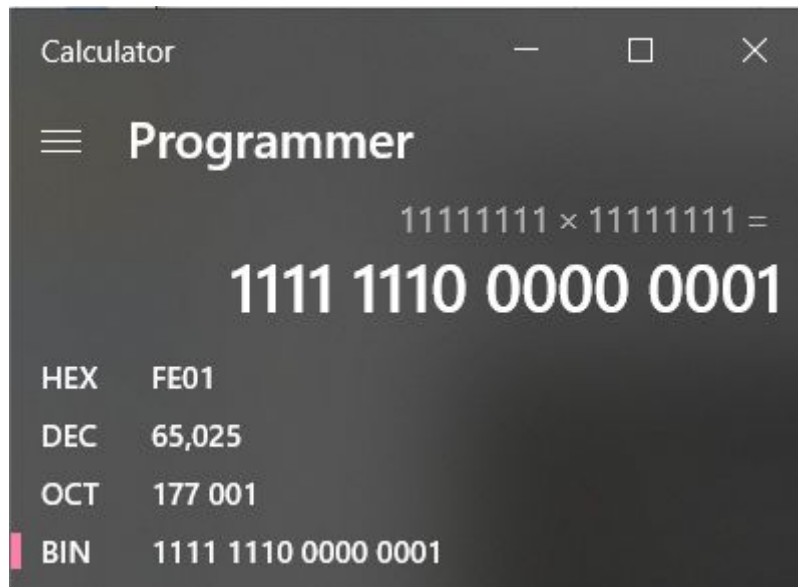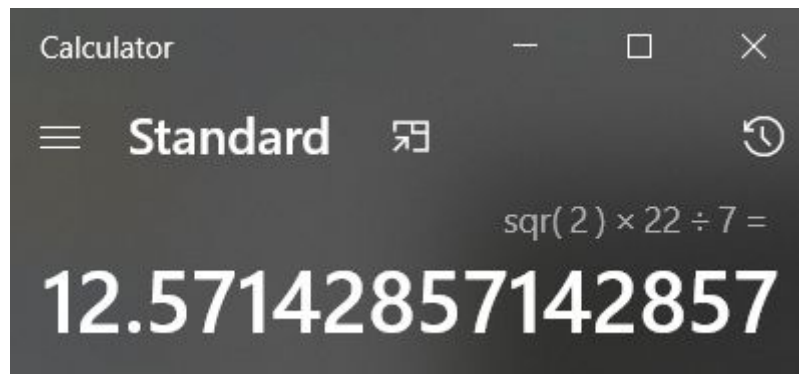
Diagram 1.8
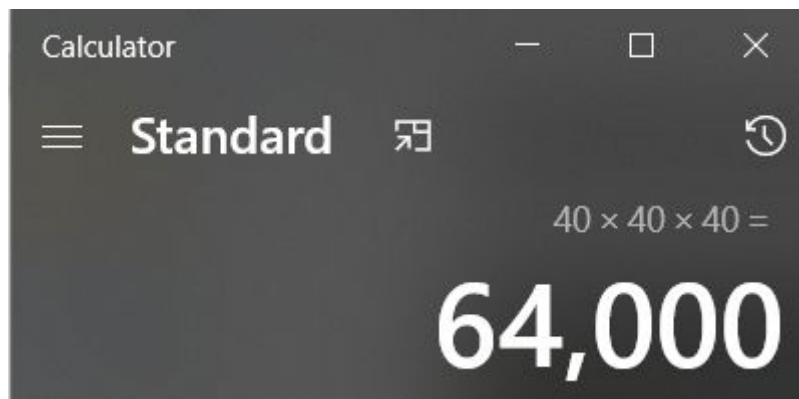

Diagram 1.9

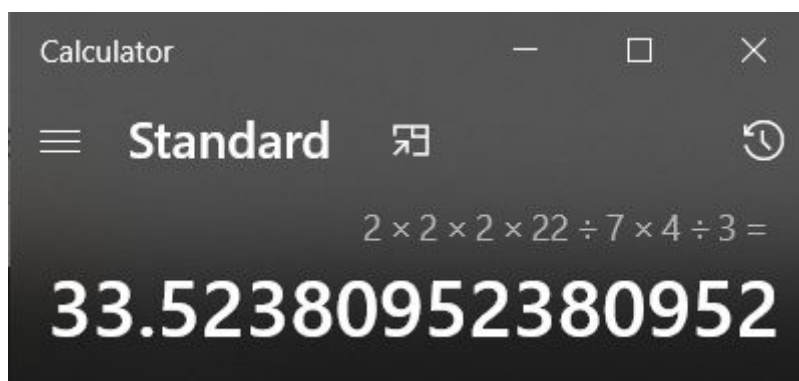Diagram 2.0

Diagram 2.1

Diagram 2.2

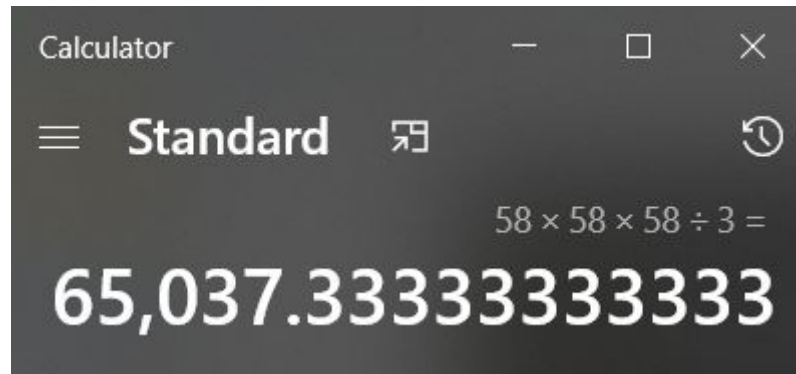Diagram 2.3

Diagram 2.4

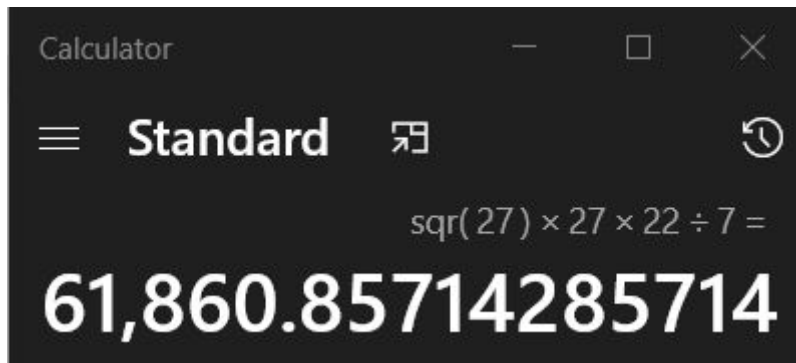Diagram 2.5

Diagram 2.6
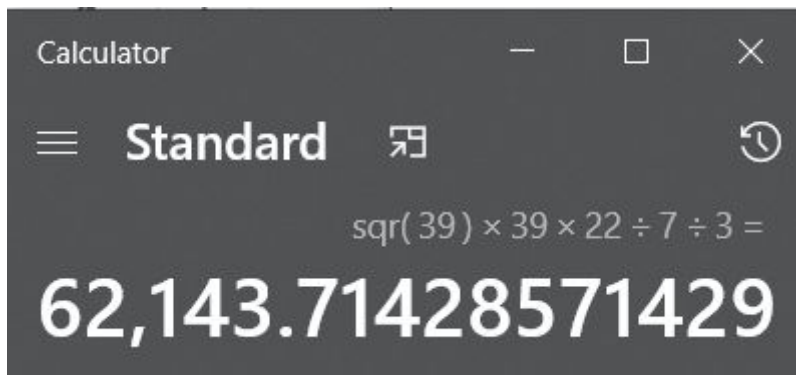

Diagram 2.7

Assignment - Assessment Rubrics

Student's Name   : (1)TEO WEN ZHI   (2)WONG WINNIE

Student's ID number : (1)20WMR09522   (2)20WMR09192

		Poor	Fair	Average	Good	Excellent
Part 1	**Marks**	**0 - 2**	**3 - 4**	**5 - 6**	**7 - 9**	**9 - 10**
Ability to deliver a clearly written proposal with the use information / digital technologies **(Group basis)**	10	Incomplete proposal with minimum used of tools	Proposal with limited information and incorrect flow chart basic efficient used of tools	Proposal with basic information and correct flow chart with some used of tools	Proposal with added information and correct flow chart with appropriate used of tools	Proposal with comprehensive details and flow chart with efficient used of tools
Part 2	**Marks**	**0 - 2**	**3 - 4**	**5 - 6**	**7 - 9**	**9 - 10**
Ability to apply required data type / data structure / comment **(Group basis)**	10	Unable to identify required data type / data structure / naming convention	Able to identify required data type / data structure correctly/ naming convention	Able to apply identify required data type / data structure / naming convention but does not produce correct result	Able to apply identify required data type / data structure / naming convention and produce partially correct result	Able to apply identify required data type / data structure /naming convention and produce correct result
Ability to apply required control structure **(Group basis)**	10	Unable to identify required control structure	Able to identify required control structure but does not apply correctly	Able to identify required control structure but does not produce correct result	Able to identify required control structure and produce partially correct result	Able to identify required control structure and produce correct result
	Marks	**0 - 3**	**4 - 6**	**7 – 9**	**10 - 12**	**13 - 15**
Ability to perform I/O validation **(Individual basis)**	15	The program produces incorrect result	The program produces correct result but does not check for error	The program produces correct result with little check for error	The program produces correct result with some check for error	The program produces correct result with comprehensive check for error
Ability to run / debug **(Individual basis)**	15	Unable to run the program	Able to run the program but with major logic errors	Able to run the program correctly but minor inappropriate logic	Able to run the program correctly without any logical error but display inappropriate output	Able to run the program correctly without any logical error and display appropriate output
Ability to develop program with advanced features **(Individual basis)**	15	Program is simple	Project is completed	Program is well designed	Program is nice with some creativity ideas	Program developed is challenging and ambitious with extra efforts