# CS205 C/ C++ Programming - Lab Assignment2

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## My codes are provided on the github https://github.com/2069958859/Project2.git ,please check it there.

## Part1-Analysis

> 1、This Project is to implement a much better calculator, I implement 6 operators: + - * / % ^ and 3 types of parentheses: () [] {} . Besides, it can calculate math functions "sqrt(x)" and be defined using "x=a".
> When I input a line of arithmetic expression, it can output the correct results.
> 2、Because there are several types of operators(+ - * / % ^ () [] {}) with different priority, I will get the correct answer after turn them into a postfix expression, and then calculate the answer using postfix expression.
>
> > Postfix expression has an advantage that the operator is evaluated in the order in which the operator appear, and the parentheses are removed, so the evaluation is easy to implement.

> 3、To support arbitrary precision, I will use string to calculate.

## Part2-Code

Here are source.cpp and arithmetic.cpp two cpp files, and source.hpp one hpp file.

The followings are some important data names:

```
stack<char> symbolStack;    //存符号的栈
stack<string> fingerStack;  //存数字的栈
stack<double> doubleFinger; //以double类型存数字的栈
vector<string> postfix;     // expression前缀表达式形式
vector<string> dataName;    //存代数式的数据名称
vector<string> Data;        //存代数式的数据值
```

In source.cpp， I will implement following methods:

> Mainly used to get postfix expressions and calculate results using stack.

```
bool isalgExp(string exp);  //检查是否为“x=1"的形式
void algexp(string algexp); //处理代数式
int getPriority(char c);
string processSymbol(string exp); //将负数转化为0-a
bool isDouble(string x);          //返回是否是浮点数（整数也判断为true)
void getPostfix(string exp);      //将表达式转化为后缀表达式
```

~~~
string erasepostZero(string str); //去掉小数点后多余的0
void assignNum();
void calculate(vector<string> post); //计算后缀表达式```

### In arithmetic.cpp, I will implement following methods:<br>

> Mainly used to auxiliary calculate result in source.cpp, based on Project1, the
method of dealing with decimal point is simplified.

```java
string findDot(string str); //查找是否有小数点，如果有，就记录小数有几位并抹去小数点
bool isNegtive(string x);
bool allZero(string str);            //检查是否为0
void process(string mm, string nn); //处理输入的数据，记录有几位小数，将小数位较少的用
0补齐
string sub(string mm, string nn);   // double 减法运算,计算mm-nn
string add(string mm, string nn);   // double 加法的运算
string multiply(string mm, string nn);//double 乘法运算
~~~

## 1、The code of turning the expression to the postfix expression:

> Here are several situations and the corresponding processing method of the expression:
> 1、operators(+ - * / ^ %): Eject elements from the stack until a lower priority element is found (or the stack is empty). After these elements are popped, the encountered operators are pushed onto the stack.
> 2、open parentheses( ( [ { ): process like the operators, but only be poped when met the corresponding close parentheses.
> 3、close parentheses( ) ] } ): pop the stack element, printing the pop operator until an open parenthesis is encountered. Note that the open parenthesis only pops up and does not output.
> 4、numbers: print it directly.
> 5、sqrt(x) function: recognize the function and put "S" on the stack as the operator.
> 6、invalid input: exit directly.

```
int getPriority(char c) // get 优先级
{
    if (c == '+' || c == '-')
    {
        return 1;
    }
    else if (c == '*' || c == '/')
    {
        return 2;
    }
    else if (c == '%' || c == '^' || c == 'S')
    {
        return 3;
    }
    else
    { //数字的情况
        return 0;
```

```
    }
}
```

```
void getPostfix(string exp) //将表达式转化为后缀表达式
{
    string temp;
    for (size_t i = 0; i < exp.size(); i++)
    {
        char flag;
        switch (exp[i])
        {
        case ')':
            flag = '(';
            break;
        case ']':
            flag = '[';
            break;
        case '}':
            flag = '{';
        }
        temp = "";
        if (exp[i] == ' ')
        { //处理输入的空格
        }
        else if (exp[i] == '+' || exp[i] == '-' || exp[i] == '*' || exp[i] == '/' 
|| exp[i] == '%' || exp[i] == '^')
        {
            if (exp[i + 1] == '+' || exp[i + 1] == '-' || exp[i + 1] == '*' || 
exp[i + 1] == '/' || exp[i + 1] == '%' || exp[i + 1] == '^')
            {
                cout << "not valid input (multiple symbols) !" << endl;
                exit(0);
            }
            else
            {
                if (symbolStack.empty() || symbolStack.top() == '(' || 
symbolStack.top() == '[' ||
                    symbolStack.top() == '{')
                {
                    symbolStack.push(exp[i]);
                }
                else
                {
                    while (!symbolStack.empty() && (getPriority(exp[i]) <= 
getPriority(symbolStack.top())))
                    {
                        temp += symbolStack.top();
                        symbolStack.pop();
                        postfix.push_back(temp);
                        temp = "";
                    }
```

```
                        symbolStack.push(exp[i]);
                    }
                }
            }
            else if (exp[i] == '(' || exp[i] == '[' || exp[i] == '{')
            {
                symbolStack.push(exp[i]);
            }
            else if (exp[i] == ')' || exp[i] == ']' || exp[i] == '}')
            {
                while (!symbolStack.empty() && symbolStack.top() != flag)
                {
                    temp += symbolStack.top();
                    symbolStack.pop();
                    postfix.push_back(temp);
                    temp = "";
                }
                if (!symbolStack.empty() && symbolStack.top() == flag)
                {
                    symbolStack.pop();
                }
            }
            else
            {
                if (isdigit(exp[i])) //数字的情况
                {
                    temp += exp[i];
                    while (exp.length() > i + 1 && (isdigit(exp[i + 1]) || exp[i + 1]
== '.'))
                    {
                        temp = temp + exp[i + 1];
                        i++;
                    }
                    if (!isDouble(temp)) //检验数字是否合法
                    {
                        cout << "not correct number!" << endl;
                        exit(0);
                    }
                    postfix.push_back(temp);
                }
                else if (exp[i] == 's' && exp[i + 1] == 'q' && exp[i + 2] == 'r' &&
                         exp[i + 3] == 't')
                { // math function sqrt(x)
                    temp += exp[i + 5];
                    while (exp.length() > i + 6 && (isdigit(exp[i + 6]) || exp[i + 6]
== '.'))
                    {
                        temp = temp + exp[i + 6];
                        i++;
                    }
                    i = i + 6;
                    postfix.push_back(temp);
                    symbolStack.push('S'); //作为sqrt函数的记号
                }
                else
                { //非法输入
                    cout << "not valid input!" << endl;
                    exit(0); //直接结束程序
                }
            }
        }
        while (!symbolStack.empty())
        {
            temp = "";
            temp += symbolStack.top();
            symbolStack.pop();
            postfix.push_back(temp);
        }
    }
```

2、The implement of calculating postfix expression:

> Since division is still difficult to achieve large precision even we using strings to calculate, the division is evaluated directly as a double, so the doubleFinger stack and fingerStack are used to record values synchronously.
> If the divisor is 0, it can get an error hint.

```
string num1, num2;
void assignNum() //从栈中取值用来计算
{
    if (!fingerStack.empty())
    {
        num2 = fingerStack.top();
        fingerStack.pop();
        doubleFinger.pop();
    }
    if (!fingerStack.empty())
    {
        num1 = fingerStack.top();
        fingerStack.pop();
        doubleFinger.pop();
    }
}
```

```
void calculate(vector<string> post) //计算后缀表达式
{
    string temp;
    double d1 = 0, d2 = 0, num = 0;
    for (int i = 0; i < post.size(); i++)
    {
        temp = post[i]; // string
        if (isdigit(temp[0]))
        {
            num = atof(temp.c_str()); //将该字符对应的字符串转化成double类型
            doubleFinger.push(num);   //以double类型存入
            fingerStack.push(temp);   //以字符串类型存入
        }
        else if (temp == "+")
        {
            assignNum();
            fingerStack.push(add(num1, num2));
            doubleFinger.push(stod(add(num1, num2)));
        }
        else if (temp == "-")
        {
            assignNum();
            fingerStack.push(sub(num1, num2));
            doubleFinger.push(stod(sub(num1, num2)));
        }
        else if (temp == "*")
        {
            assignNum();
            fingerStack.push(multiply(num1, num2));
            doubleFinger.push(stod(multiply(num1, num2)));
        }
        else if (temp == "/")
        {
            if (!fingerStack.empty())
            {
                d2 = doubleFinger.top();
                fingerStack.pop();
                doubleFinger.pop();
            }
            if (!fingerStack.empty())
            {
                d1 = doubleFinger.top();
                fingerStack.pop();
                doubleFinger.pop();
            }
            if (d2 == 0)
            {
                cout << "错误：除数为0" << endl;
                exit(0);
            }
            else
            {
                fingerStack.push(erasepostZero(to_string(d1 / d2)));
                doubleFinger.push(d1 / d2);
            }
        }
        else if (temp == "^")
        {
            if (!fingerStack.empty())
            {
                d2 = doubleFinger.top();
                fingerStack.pop();
                doubleFinger.pop();
            }
            if (!fingerStack.empty())
            {
                d1 = doubleFinger.top();
                fingerStack.pop();
                doubleFinger.pop();
            }
            fingerStack.push(erasepostZero(to_string(pow(d1, d2))));
            doubleFinger.push(pow(d1, d2));
        }
        else if (temp == "%")
        {
            if (!fingerStack.empty())
            {
                d2 = doubleFinger.top();
                fingerStack.pop();
                doubleFinger.pop();
            }
            if (!fingerStack.empty())
            {
                d1 = doubleFinger.top();
                fingerStack.pop();
                doubleFinger.pop();
            }
            fingerStack.push(erasepostZero(to_string(fmod(d1, d2))));
            doubleFinger.push(fmod(d1, d2)); // fmod可以小数求余
        }
        else if (temp == "S")
        { // sqrt(x) function
            if (!fingerStack.empty())
            {
                d2 = doubleFinger.top();
                fingerStack.pop();
                doubleFinger.pop();
            }
            fingerStack.push(erasepostZero(to_string(sqrt(d2))));
            doubleFinger.push(sqrt(d2)); // sqrt 函数开平方
        }
    }
}
```

3、Deal with algebraic expression

```
void algexp(string algexp)
{ //处理代数式
    string dataname = "";
    string temp = "";
    double data;
    if (isalgExp(algexp))
    {
        dataName.push_back(algexp.substr(0, equalmark));
        Data.push_back(algexp.substr(equalmark + 1, algexp.size()));
    }
}
```

## 4、main function

> If the assignment is not complete, it will keep input line， it will terminate when we input "exit", or it will wait for the next expression.

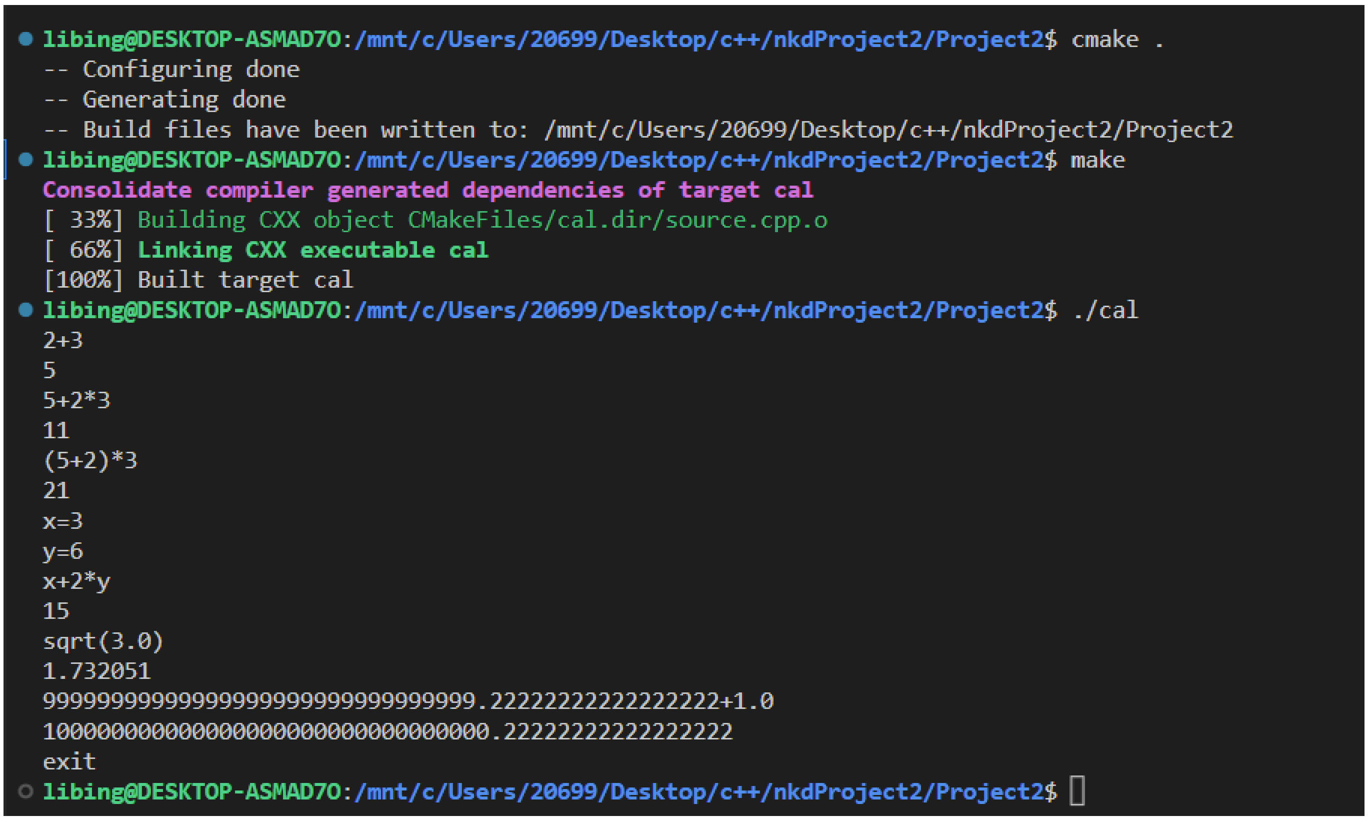
```
int main()
{
    string expression;
    while (true)//可以一直计算直到遇到“exit”
    {
        getline(cin, expression);
        algexp(expression);
        if (expression == "")//输入回车的情况
        {
        }
        else if (isExit(expression))
        {
            break;
        }
        else if (expression == "help")//打印帮助文档
        {
            help();
        }
        else
        { //替换常数
            int placePI = expression.find("PI");
            while (placePI != -1)
            {
                expression.replace(placePI, 2, "3.14159265358");
                placePI = expression.find("PI");
            }
            int placeE = expression.find("E");
            while (placeE != -1)
            {
                expression.replace(placeE, 1, "2.718281828459");
                placeE = expression.find("E");
            }

            while (isalgExp(expression)) //是给变量赋值的式子
            {
                getline(cin, expression);
                algexp(expression);
            }
            for (int i = 0; i < dataName.size(); i++)
            { //将式子中的变量名替换成值
```

```
                int place = expression.find(dataName[i]);
                while (place != -1)
                {
                    expression.replace(place, dataName[i].length(), Data[i]);
                    place = expression.find(dataName[i]);
                }
            }
            expression = processSymbol(expression);
            getPostfix(expression);
            calculate(postfix);
            cout << fingerStack.top() << endl;

            dataName.clear(); //清空之前的信息
            Data.clear();
            postfix.clear();
            clearStack(); //将栈清空
        }
    }
    return 0;
}
```

## Part 3 - Result & Verification

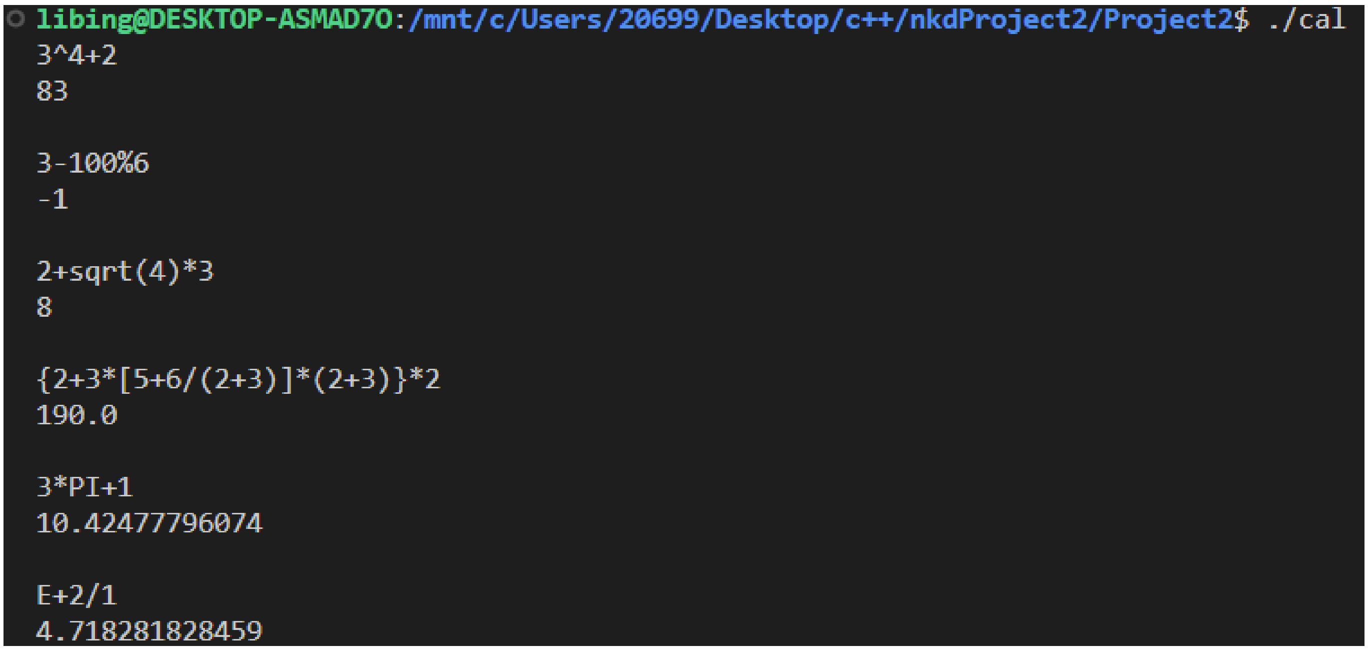
1、I use cmake to manage the source files and get the right answers for the given test cases, it will stop when input "exit".:

```
project(hello)
add_executable(cal source.cpp arithmetic.cpp )
```



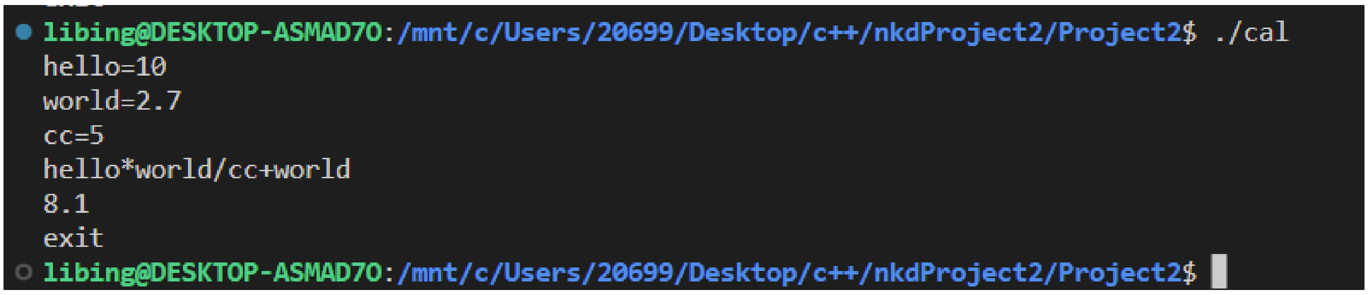
```
● libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ cmake .
  -- Configuring done
  -- Generating done
  -- Build files have been written to: /mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2
● libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ make
  Consolidate compiler generated dependencies of target cal
  [ 33%] Building CXX object CMakeFiles/cal.dir/source.cpp.o
  [ 66%] Linking CXX executable cal
  [100%] Built target cal
● libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
  2+3
  5
  5+2*3
  11
  (5+2)*3
  21
  x=3
  y=6
  x+2*y
  15
  sqrt(3.0)
  1.732051
  999999999999999999999999999999999.22222222222222222+1.0
  1000000000000000000000000000000000.22222222222222222
  exit
○ libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ 
```

2、other test cases:

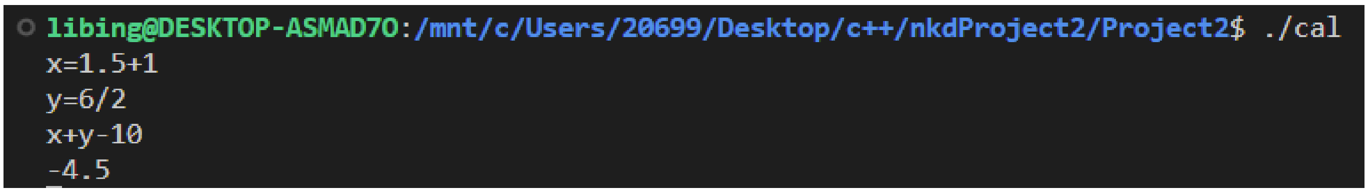


```
○ libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
  3^4+2
  83

  3-100%6
  -1

  2+sqrt(4)*3
  8

  {2+3*[5+6/(2+3)]*(2+3)}*2
  190.0

  3*PI+1
  10.42477796074

  E+2/1
  4.718281828459
```

Variables can be definited with any names made up of letters: x, y, zz, hello .etc, and variables can be used many times. Besides, it can be defined by an expression:

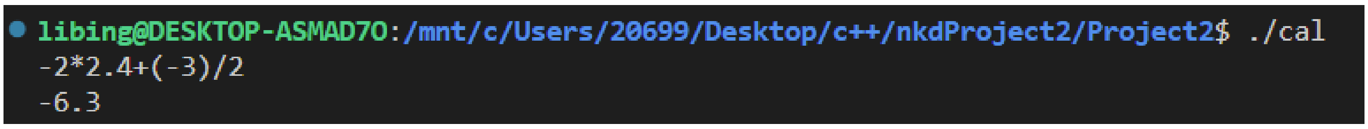


```
libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
hello=10
world=2.7
cc=5
hello*world/cc+world
8.1
exit
libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$
```



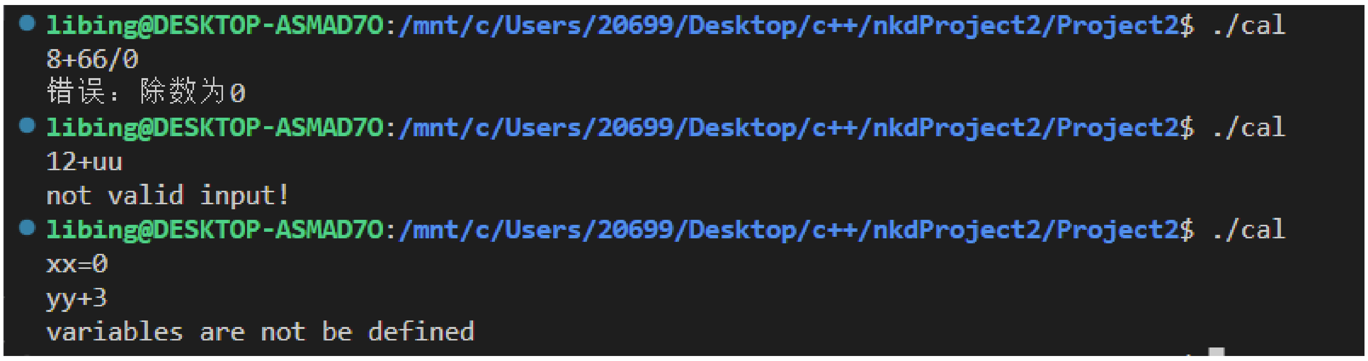
```
libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
x=1.5+1
y=6/2
x+y-10
-4.5
```

And it can support negative calculating:

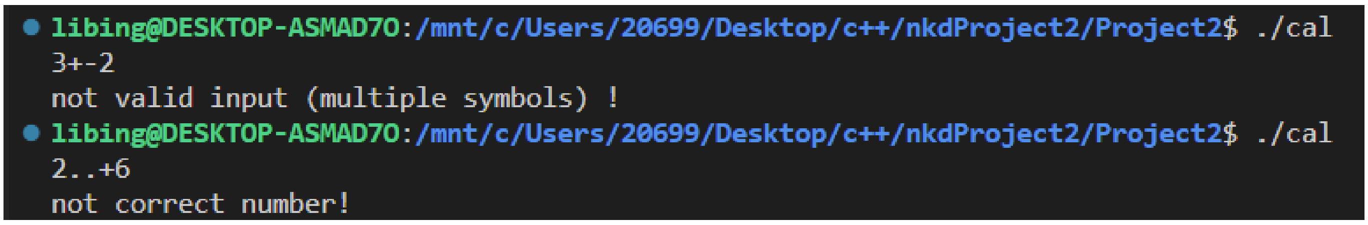


```
libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
-2*2.4+(-3)/2
-6.3
```

It can also detect invalid situations:

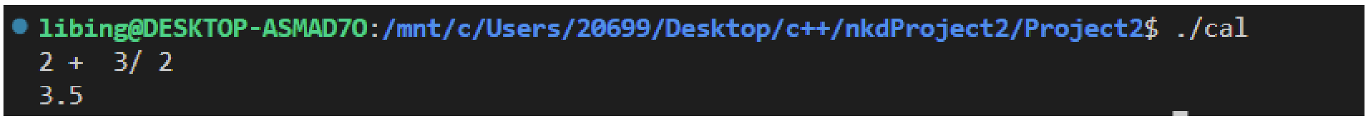


```
libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
8+66/0
错误: 除数为0
libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
12+uu
not valid input!
libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
xx=0
yy+3
variables are not be defined
```



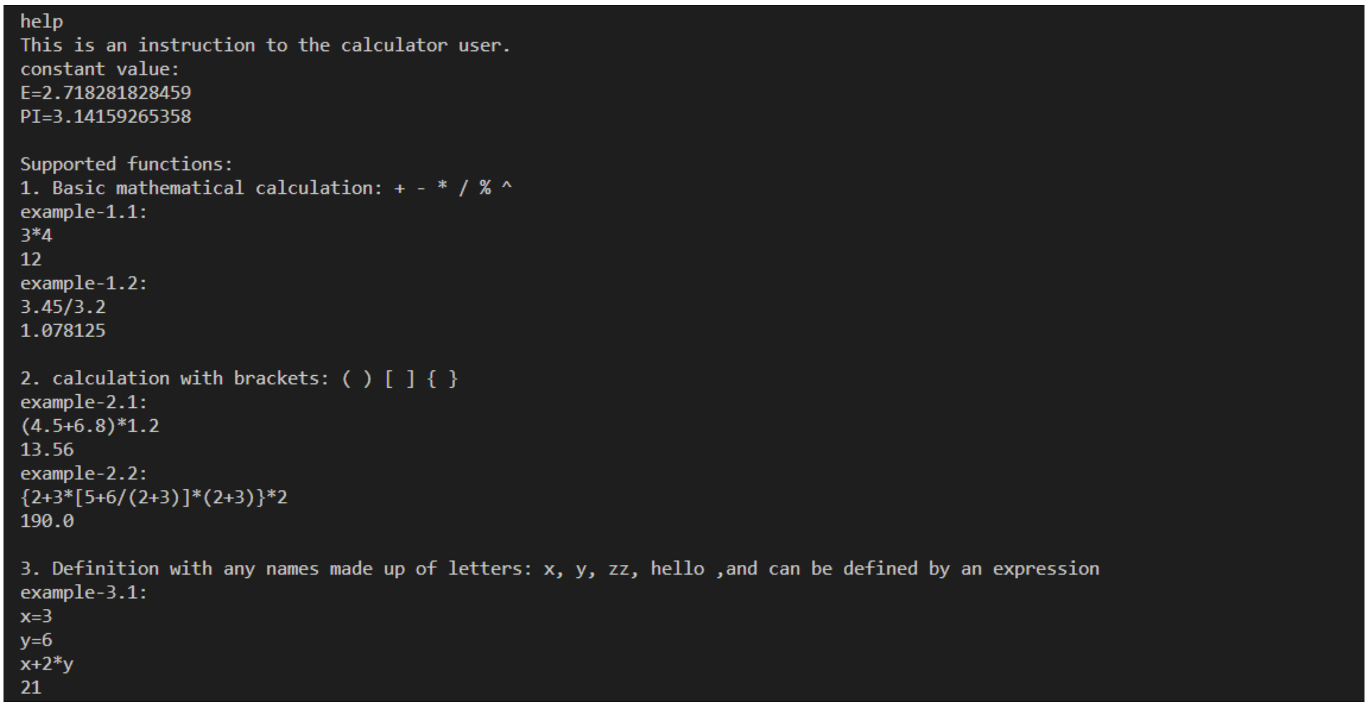
```
libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
3+-2
not valid input (multiple symbols) !
libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
2..+6
not correct number!
```

if there are some blanks, it can calculate correctly:



```
libing@DESKTOP-ASMAD7O:/mnt/c/Users/20699/Desktop/c++/nkdProject2/Project2$ ./cal
2 +  3/ 2
3.5
```

Here is a help documentation which can tell users how to use it when input "help":(I will show only part of it)



```
help
This is an instruction to the calculator user.
constant value:
E=2.718281828459
PI=3.14159265358

Supported functions:
1. Basic mathematical calculation: + - * / % ^
example-1.1:
3*4
12
example-1.2:
3.45/3.2
1.078125

2. calculation with brackets: ( ) [ ] { }
example-2.1:
(4.5+6.8)*1.2
13.56
example-2.2:
{2+3*[5+6/(2+3)]*(2+3)}*2
190.0

3. Definition with any names made up of letters: x, y, zz, hello ,and can be defined by an expression
example-3.1:
x=3
y=6
x+2*y
21
```

## Part 4 - Problems & Summary

### 1、problem

When I calculate with double, the string stack can't record the result, so in the calculate method I calculate with both stacks in parallel, using to_string () to convert double to string, but in this way, the result will keep 6 decimals. Like 1.000000, so I write a method erasepostZero to get rid of any extra zeros after the decimal point:

```
string erasepostZero(string str) //去掉小数点后多余的0
{
    string ans;
    int dot = str.find(1, '.');
    int zeros = 0;
    for (int i = str.size() - 1; i >= dot; i--)
    {
        if (str[i] == '0' || str[i] == '.')
        {
            zeros++;
        }
        else
        {
            break;
        }
    }
    ans = str.substr(0, str.size() - zeros);
    return ans;
}
```

and use it in the calculate method:

```
fingerStack.push(erasepostZero(to_string(d1 / d2)));
doubleFinger.push(d1 / d2);
```

### 2、summary

I gained a lot from this project. First of all, I learned how to use stacks, and the conversion and meaning between infix and postfix expressions. Secondly, I also improved the problem that the decimal point was very jumbled（冗杂） in the last project calculation, to solve it, I handled it directly in the method. As followings, take multiplication as an example.

```
string findDot(string str) //查找是否有小数点，如果有，就记录小数有几位并抹去小数点
{
    string a = str;
    dot = a.find(".", 1);
    if (dot != -1)
    {
        a.erase(dot, 1);
        dot = str.length() - dot - 1; //计算小数点后有几位
    }
    else
    { //无小数点，即有0位小数
        dot = 0;
    }
    return a;
}
```

```
string multiply(string mm, string nn)
{
    int dotsum = 0;
    string m = findDot(mm);
    dotsum = dot;
    string n = findDot(nn);
    dotsum += dot;
    bool negative = false;
    if (isNegtive(mm))
    {
        m = m.substr(1, mm.length());
    }
    if (isNegtive(nn))
    {
        n = n.substr(1, nn.length());
    }
    if ((isNegtive(mm) && !isNegtive(nn)) || (!isNegtive(mm) && isNegtive(nn)))
    {
        negative = true;
    }
    if (m.size() < n.size() || (m.size() == n.size() && m < n))
    { //保证m大
```

```
            swap(m, n);
        }
        int a = m.size();
        int b = n.size();
        int flag = 0;
        string ans;
        for (int i = b - 1; i >= 0; i--)
        {
            flag = 0;
            string aa(b - i - 1, '0');
            for (int j = a - 1; j >= 0; j--)
            {

                flag = flag + (m[j] - '0') * (n[i] - '0');
                aa.append(to_string(flag % 10));
                flag = flag / 10;
            }
            if (flag != 0)
            {
                aa.append(to_string(flag));
            }

            reverse(aa.begin(), aa.end());
            ans = add(ans, aa);
        }

        if (dotsum != 0)
        {
            flag = 0;
            for (int i = 0; i < ans.size() - dotsum - 1; i++)
            {
                if (ans[i] == '0')
                {
                    flag++;
                }
            }
            ans = ans.substr(flag, ans.size()); //除去前面的0
            ans = ans.insert(ans.length() - dotsum, ".");
        }
        if (negative)
        {
            ans = "-" + ans;
        }
        return ans;
    }
```

When I do substraction and addition, I will process it first:

```
    void process(string mm, string nn)
    { //处理输入的数据，记录有几位小数，将小数位较少的用0补齐
        m = findDot(mm);
        dot1 = dot;
        n = findDot(nn);
        dot2 = dot;
        if (dot1 != 0 || dot2 != 0)
        { //补齐位数
            if (dot1 >= dot2)
            { // m的小数位多
                n.append(dot1 - dot2, '0');
                dot = dot1;
            }
            else if (dot1 < dot2)
            {
                m.append(dot2 - dot1, '0');
                dot = dot2;
            }
        }
    }
```