

Programming Project 4

Due: Thursday, 3/12/15 at 11:59 pm

Infix Expression Evaluator

For this lab, write a C program that will evaluate an infix expression. The algorithm REQUIRED for this program will use two stacks, an operator stack and a value stack. Both stacks MUST be implemented using a linked list.

The commands used by this system are listed below and are to come from standard input. Your program is to prompt the user for input and display error messages for unknown commands. The code in proj4.c already does this for you. You are expected to use that code as the base for your project.

Command	Description
q	Quit the program.
?	List the commands used by this program and a brief description of how to use each one.
<infixExpression>	Evaluate the given infix expression and display its result.

The **<infixExpression>** will only use the operators of addition, subtraction, multiplication, division and the parentheses. It will also only contain unsigned (i.e. positive) integer values. We obviously could allow for more operators and more types of values, but the purpose of this assignment is to focus on linked list structures and not on complicated arithmetic expressions.

Infix Expression are when the operators of addition, subtraction, multiplication and division are listed IN between the values. Infix Expressions require the use of parentheses to express non-standard precedence. Examples of Infix Expressions are:

```
42 + 64
60 + 43 * 18 + 57
(60 + 43) * (18 + 57)
18 - 12 - 3
18 - (12 - 3)
```

Postfix Expressions are when the operators of addition, subtraction, multiplication and division are list AFTER (i.e. “post”) the values. Postfix Expression never require the use of parentheses to express non-standard precedence. The fact that postfix expressions do not need parentheses makes them much easier to evaluate than infix expressions. In fact, most computers first convert infix expression to a postfix expression and then evaluate that postfix expression.

A postfix expression is evaluated using a stack. When a value is encountered, it is pushed onto the stack. When an operator is encountered, two values are popped from the stack. Those values are evaluated using the operation implies by the operator. Then the result is pushed back onto the stack. When the end of a postfix expression is encountered, the value on the top of the stack is the result of the expression. There should only be one value on the stack when the end of the postfix expression is encountered.

Examples of Postfix Expressions are:

```
42 64 +
60 43 18 * + 57 +
60 43 + 18 57 + *
18 12 - 3 -
18 12 3 - -
```

Both the algorithm to convert an infix expression to a postfix expression and the algorithm to evaluate a postfix expression require the use of stacks. Note that the conversion algorithm requires a stack of operators, while the evaluation algorithm requires a stack of values.

For this program, you are to write the following functions for the linked list stacks:

```
int isEmpty (stack);           // return TRUE if the stack has no members
void push (stack, data);      // add the data to the top of the stack
data top (stack);            // return the data value on the top of the stack
void pop (stack);            // remove the data value from the top of the stack
```

You may also wish to write a “topPop()” function that does both the top and pop operations in a single function. Also, note that since the values from the infix expressions will all be integer values (we will only do integer division), and since the operators can all be represented as characters (which is a sub-class of integers), you are more than welcome to write a single linked list structure to be used for both stacks.

The pointer for the head of each linked list **MUST** be declared on the stack as a local variable to some function (it may be as a local variable to a function other than main). **It may NOT be global.** Each operation performed on the linked list **MUST** be done in its own function. These functions must take the head of the linked list (or a structure containing the head of the linked list) as its **FIRST** parameter.

Algorithm for Infix to Postfix Conversation and Postfix Evaluation

First we will define the function popAndEval () as follows:

```
op = top (OperatorStack)
pop (OperatorStack)
v2 = top (ValueStack)
pop (ValueStack)
v1 = top (ValueStack)
pop (ValueStack)
v3 = eval ( v1, op, v2 )
push (ValueStack, v3)
```

If you are trying to perform a top operation on an empty ValueStack, print out an error message and return the value of -999. If the operator op for eval () is not one of *, /, + or -, print out an error message and return the value of -999.

When getting the input for an infix expression, the program **proj4.c** breaks everything down into “tokens”. There are 3 types of tokens we are concerned with: an OPERATOR token, a VALUE token and the EndOfLine token. The code in the function processExpression() already checks for these token but you will need to add the code how to interact with the stacks.

First step:

Set both the OperatorStack and the ValueStack empty

Second Step:

```

While (the current token is not the EndOfLine Token)
  if ( the current token is a VALUE )
    push the value onto the ValueStack
  if ( the current token is an OPERATOR )
    if ( the current operator is an Open Parenthesis )
      push the Open Parenthesis onto the OperatorStack
    if ( the current operator is + or - )
      while ( the OperatorStack is not Empty &&
              the top of the OperatorStack is +, -, * or / )
        popAndEval ( )
      push the current operator on the OperatorStack
    if ( the current operator is * or / )
      while ( the OperatorStack is not Empty &&
              the top of the OperatorStack is * or / )
        popAndEval ( )
      push the current operator on the OperatorStack
    if ( the current operator is a Closing Parenthesis )
      while ( the Operator Stack is not Empty &&
              the top of the OperatorStack is not an Open Parenthesis )
        popAndEval ( )
    if (the OperatorStack is Empty )
      print an error message
    else
      pop the Open Parenthesis from the OperatorStack
  get the next token from the input

```

Third Step:

```

Once the EndOfLine token is encountered
  while (the OperatorStack is not Empty )
    popAndEval ( )
  Print out the top of the ValueStack at the result of the expression
  Popping the ValueStack should make it empty, print error if not empty

```

The error statements in the above algorithm should only occur if an invalid infix expression is given as input. You are not required to check for any other errors in the input.

Command Line Argument: Debug Mode

Your program is to be able to take one optional command line argument, the `-d` flag. When this flag is given, your program is to run in "debug" mode. When in this mode, your program should display the operators and values as they are encountered in the input. The `printf` statements for these are already included in the program `proj4.c`.

When the flag is not given, this debugging information should not be displayed. One simple way to set up a "debugging" mode is to use a boolean variable which is set to true when debugging mode is turned on but false otherwise. This variable may be a global variable. Then using a simple if statement controls whether information should be output or not.

```
if ( debugMode == TRUE )
    printf (" Debugging Information \n");
```

Provided Code for the User Interface

The code given in `proj4.c` should properly provide for the user interface for this program including all command error checking. This program has no code for the linked list. It is your job to write the functions for the specified operations and make the appropriate calls. Most of the changes to the existing `proj6.c` program need to be made in the `processExpression ()` function. Look for the comments of:

```
// add code to perform this operation here
```

Note: the heads of the linked list are required to be a local variable in a function and you are required to pass the head of the linked to the operation functions. The function `processExpression()` is strongly suggested as the functions in which to declared the linked lists.

MULTIPLE SOURCE CODE FILES

Your program is to be written using at least two source code files. It must also have a makefile to help with the compilation of the program and a header file to reduce the amount of duplicated code in the source code files. All of the storage structure code (the linked list code) is to be in one source code file. While the other file (or files if you wish to have more than two source code files) would contain the remainder of the program.

The makefile MUST separately compile each source code file into a ".o" file and separately link the ".o" files together into an executable file.

Program Submission

You are to submit the programs for this lab via the Assignments Page in [Blackboard](#).

To help the TA, name your file with your net-id and the assignment name, like:

- `ptroy1LabX.c`