1. **Problem Statement**

Create a program that takes an infix equation as input, the processes it into an expression tree and prints the traversals in prefix, infix, and postfix.

1. **Requirements**
   1. **Assumptions**

* A minimum of one space will be on each side of a character in the file
* Only single uppercase characters are used as operands
  1. **Specifications**
* Print a welcome message when the program starts
* Must read inputs from a file
  + Echo all inputs back to the user
  + User should enter the file name
    - Verify that the file exists
    - Verify the file is of the correct type (.dat file extension)
  + Check that the file is in the correct format
    - Each line should contain only one expression
    - Characters should have one space between them
* Convert the expression to postfix and print the operations that would be performed to solve the expression
* Build an expression tree of the equation
  + Traverse the tree and print the results in infix, postfix, and prefix
  + Evaluate the expression using prefix notation
    - Print each step of the evaluation and the corresponding result
  + Print the tree structure to the screen
* Expression variable values
  + A = 1, B = 2, C = 3 …
* Print all errors and outputs to a file called output.dat
  + Verify that parentheses match up
  + Check for 2 operators for each operand
* Print a message stating that program has completed

1. **Decomposition Diagram**

Main

Input

Print all results and errors to the screen and to a file

Evaluate the expression using prefix notation

Checks the file for errors

Reads the expressions from the input file

Converts each expression to postfix and traverse it through an expression tree

User enters the filename for the input file

Output

Process

1. **Test Strategy**

* Valid
  + Test valid expressions and formats that should NOT throw any errors.
* Invalid
  + Test invalid expressions and formats that SHOULD throw errors.
* File Handling
  + Test file functions

1. **Test Plan Version 1**

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| --- | --- | --- | --- | --- | --- | --- |
| Test Strategy | Test Number | Description | Input | Expected Output | Actual Output | Pass/Fail |
| Valid | 1.1 | Test expression with 1 operator and no parentheses or operands |  |  |  |  |
| Valid | 1.2 | Test expression with 2 values, + operator, no parentheses |  |  |  |  |
| Valid | 1.3 | Test expression with 2 values, - operator, no parentheses |  |  |  |  |
| Valid | 1.4 | Test expression with 2 values, \* operator, no parentheses |  |  |  |  |
| Valid | 1.5 | Test expression with 2 values, / operator, no parentheses |  |  |  |  |
| Valid | 1.6 | Test expression with 2 values, 1 operator, all enclosed in parentheses |  |  |  |  |
| Valid | 1.7 | Test expression with 3 values, operation with 2 values enclosed in parentheses, first operation added to 3rd operator |  |  |  |  |
| Valid | 1.8 | Test expression with 3 values, operation with 2 values enclosed in parentheses, first operation divided by 3rd operator |  |  |  |  |
| Valid | 1.9 | Test expression with 3 values, operation with 2 values enclosed in parentheses, first operation multiplied by 3rd operator |  |  |  |  |
| Valid | 1.10 | Test expression with 3 values, operation with 2 values enclosed in parentheses, first operation subtracted from 3rd operator |  |  |  |  |
| Valid | 1.11 | Test expression with a combination of operations inside and outside of the parentheses |  |  |  |  |
| Valid | 1.12 | Test order of operations at the same level: \*, /. +, - |  |  |  |  |
| Valid | 1.13 | Test order of operations at the same level: +, -, \*, / |  |  |  |  |
| Valid | 1.14 | Test order of operations at the same level: \*, +, /, - |  |  |  |  |
| Valid | 1.15 | Test order of operations at the same level: +, /. +, \* |  |  |  |  |
| Valid | 1.16 | Test order of operations between operations separated by parentheses (-)\*(+) |  |  |  |  |
| Valid | 1.17 | Test order of operations between operations separated by parentheses (\*)-(/) |  |  |  |  |
| Valid | 1.18 | Test order of operations between operations separated by parentheses (\*)/(+) |  |  |  |  |
| Invalid | 2.1 | Test an expression with 2 operands, 1 operator, and only an opening parenthesis at the begging and no closing parenthesis |  |  |  |  |
| Invalid | 2.2 | Test an expression with 2 operands, 1 operator, and only a closing parenthesis at the end |  |  |  |  |
| Invalid | 2.3 | Test an expression with 2 operands and no operators |  |  |  |  |
| Invalid | 2.4 | Test an expression with 1 operand and 1 operator |  |  |  |  |
| Invalid | 2.5 | Test an expression with no operands and 1 operator |  |  |  |  |
| Invalid | 2.6 | Test an expression with only a set of parentheses |  |  |  |  |
| Invalid | 2.7 | Test an expression with two operations and a missing closing parenthesis |  |  |  |  |
| Invalid | 2.8 | Test an expression with two operations and a missing opening parenthesis |  |  |  |  |
| Invalid | 2.9 | Test an expression with two operations enclosed in parentheses and no operator between them |  |  |  |  |
| File Handling | 3.1 | Input a file name that does not exist |  |  |  |  |
| File Handling | 3.2 | Input a file with a type other than “.dat” |  |  |  |  |
| File Handling | 3.3 | Input a file of type “.dat” that exists |  |  |  |  |
| File Handling | 3.4 | Input a file of type “.dat” that exists, but is empty |  |  |  |  |
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1. **Initial Algorithm**

* Main Method (called on program startup)
  + Open the output file “output.dat” for writing
    - All out put displayed to the screen will also be wrote to this file
  + Display a welcome message to the user
  + Ask the user to enter the location of the file they want to run through the program. (ex: [c://users//](../../../../c://users//)…//filename.dat)
  + If the file does not exist
    - Display an error message that it doesn’t exist and ask the user to enter another file name
  + If the file is empty
    - Display an error message that the file is empty and ask the user to enter another file name
  + If the file is of the wrong type (not “.dat”)
    - Display an error message that the file is of the wrong type and ask the user to enter another file name
  + Open the file and print a message that the file was opened successfully
  + For each line in the input file
    - read the line in and print it to the screen
    - string variable for the postfix expression
    - pass the expression to the function that converts infix to postfix
      * set the postfix variable equal to the return of this function
    - if the postfix variable is empty (an error must have occurred)
      * move to the next line in the file
    - if the postfix vairable is not empty (means it was converted successfully)
      * call the function displayPostfixOperations and pass the postfix string variable as a parameter
* Function to display the postfix operations
  + accepts an expression string in postfix notation as an input parameter
  + create a new queue object, queue1
  + create a new queue object, queue2
  + for each character in the input string
    - if character is an operand
      * en-queue the character in queue1
    - if the character is an operator
      * if queue1 is not empty
        + en-queue the character in queue1
        + create a new string variable
        + while the queue1 is not empty

dequeue from queue1 and add it to the string variable

* + - * + display the value of the string variable as an operation
        + en-queue the operation that is in the string variable to queue2
      * if queue1 is empty and queue2 is not empty
        + en-queue the character to queue2
        + create a new string variable
        + while queue2 is not empty

dequeue from queue 2 and add it to the string variable

* + - * + display the value of the string variable as an operation
        + en-queue the string value of the operation to queue2
      * if queue1 is empty and queue2 is empty
        + display an error that there are no operands for the operation to be performed on, and display the character.
        + return from the function, do not continue processing the inputted postfix expression
* class for a string queue (used for determining the operation steps of expressions)
  + variable that points to the first element in the queue
  + struct object for the queue
    - string variable for the operation
    - variable that points to the next value in the queue
  + function to en-queue a string
    - accepts a string input paramter
    - if the first element is empty
      * create a new struct object and set the string variable equal to the string input
      * set the first element equal to the new struct object
    - if the first element is not empty
      * create a new struct object and set the string variable equal to the string input
      * variable that points to a struct object, set equal to the first element, called current
      * while current is not null
        + set current equal to current next
      * set current equal to the new struct object that contains the input string
  + function to de-queue the first element from the queue
    - if the queue is not empty
      * create a new struct object that points to the next object of first element
      * create a string variable that is equal to the string in the first element
      * set the first element variable equal to the new struct object
      * unallocate the memory for the new struct object and delete the object
      * return the string variable
    - if the queue is empty
      * display an error that the queue is empty
      * return an empty string
  + function to check if the queue is empty
    - if the first element is null, then return true
    - if the first element is not null, then return false
* Function to convert infix to postfix
  + accepts an expression string as an input parameter
  + create an empty variable for the postfix expression string
  + create an empty character stack
  + variable for the index of the previous character, operands and operators
  + variable for the parentheses count
  + boolean variable for errors, set to false
  + for each character index
    - if character is a space
      * Change index to the next character
      * If previous character is an operand and current character is an operand
        + display an error that there are two operands in a row in the expression
        + set error variable to true
      * if previous character is an operator and current character is an operator or “)”
        + display an error that there are invalid operands for the operator
        + set error variable to true
      * if previous character is an “)” and the current character is an “(“
        + display an error that there is no operator for the operands
        + set error variable to true
      * if character index is a space
        + display an error that there are two spaces in a row \*\*\*
        + set error variable to true
      * if character index is out of bounds
        + if the postfix string variable is empty

display an error that the expression on the current line is empty

set error variable to true

* + - * + if the postfix string variable is not empty

the string is done being parsed

* + - * If character index is an operand (call checkOperand function)
        + Add the character to the end of the postfix string variable
      * If character index is an operator (call the checkOperator function)
        + While the stack is not empty and top of stack is not “(“ and top of stack is high precedence than the operator

Pop the top of the stack and add it to the postfix sting variable

* + - * + Push the current operator character to the stack
      * If the character index is a “(“
        + push it to the character stack
        + increase parentheses count by 1
      * if the character index is a “)”
        + while the stack is not empty and the top of the stack is not “(“

pop the top character from the stack and add it to the postfix string variable

* + - * + pop the top character from the stack to discard it, it should be a “(“
        + decrease the parentheses count by 1
      * increase the character index by 1
    - While the stack is not empty
      * Pop the rest of the values from the stack and add them to the string variable
  + if parentheses count is not equal to 0
    - display an error that there are mismatched parentheses
    - set error variable to true
  + if error variable is false
    - return postfix
  + if error variable is true
    - return a empty string
* Function to check if a character is an upper case operand
  + accepts a single character parameter
  + if the input character is >= ‘A’ and <= ‘Z’, return true
  + otherwise return false
* Function to check if a character is an operator
  + accepts a single character parameter
  + if input is a +, -, /, \*
    - return true
  + otherwise return false
* Function to get the weight of the operators
  + accepts a single character parameter
  + if character is ‘+’ or ‘-’
    - return 1
  + if character is ‘\*’ or ‘/’
    - return 2
* Class for the character stack
  + private variable that points to the top object of the stack
  + create a structure within the class that contains
    - a character value
    - variable that points to the next object in the stack
  + function to push a new character to the stack
    - accepts a single character as an input parameter
    - if stack is empty
      * create a new struct object and set the character value equal to the input parameter
      * set the private top variable equal to the newly created struct object
    - if the stack is not empty
      * create a new struct object and set the character value equal to the input parameter
      * set the next variable in the new object equal to the private top object
      * set the top object equal to the new object
  + function to check if stack is empty
    - if private top variable is a valid value that points to a struct object, return false
  + Function to pop the top value off the stack
    - if the stack is not empty
      * create a new struct variable and set it equal to the top variable
      * set the top variable equal to next value of top variable
      * unallocate memory for the new struct variable
  + Function to return the value of the top of the stack
    - if stack is not empty
      * return the character value of the top of the stack
    - if stack is empty, return a null character value

1. **Test Plan Version 2**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test Strategy | Test Number | Description | Input | Expected Output | Actual Output | Pass/Fail |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

1. **Code**

A baseline for commenting is before any function add this:

//Description: What does the function do

//Pre-condition: What do input do you need for the function to work

//Post-condition: What is the end result of the function or what do you get out of the function

Also the beginning of your program should have these comments:

//Program Name:

//Programmer Name:

//Description:

//Date Created:

1. **Updated Algorithm**
2. **Test Plan Version 3**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test Strategy | Test Number | Description | Input | Expected Output | Actual Output | Pass/Fail |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

1. **Screenshots**
2. **Error Log**

|  |  |  |
| --- | --- | --- |
| Error Type | Cause of Error | Solution to Error |
|  |  |  |
|  |  |  |

1. **Status**