Introduction

For your second programming assignment, you are to implement a infix expression calculator using a stack and a queue.

I/O

Your executable must be named matilda. The executable reads in a series of strings or numbers, either from a file or from stdin, and will produce, on stdout, whether or not each of the inputs is a palindrome. Here is an example invocation:

```
$ echo 999 * 8888 ; > items
$ matilda items
8879112
$
```

where $ is the system prompt. The file to be processed (items in the example) is a free-format text file. That is, the numbers, variables, operators, and semicolons found within are separated by arbitrary amounts of whitespace (i.e. spaces, tabs, and newlines) and every line ends with a newline. If a file name is not given, input is to be read from the keyboard:

```
$ matilda
999 * 8888 ;
8879112
$
```

Keyboard input is ended by entering a ^D character.

The executable must handle the following options:

<table>
<thead>
<tr>
<th>option</th>
<th>example</th>
<th>action</th>
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</thead>
<tbody>
<tr>
<td>-v</td>
<td>matilda -v</td>
<td>give author’s name and exit</td>
</tr>
<tr>
<td>-d</td>
<td>matilda -d FILENAME</td>
<td>print the postfix conversion of the last infix expression found in FILENAME instead of printing the answer</td>
</tr>
<tr>
<td></td>
<td>matilda -d</td>
<td>print the postfix conversion of the last infix expression read in from stdin instead of printing the answer</td>
</tr>
</tbody>
</table>

Here are some example invocations using options:

```
$ matilda -v
Alyssa P. Hacker
$ matilda -d
var a = 3 ;
var b = 4 ;
b + a ;
b * a ;

b a * ;
$
```

The last expression shown, b a * ; is the postfix conversion of the last expression entered, b * a ;. Here is another example:

```
$ echo var a = 3 \; > expr
$ echo var b = 4 \; >> expr
$ echo b + a \; >> expr
$ echo b * a \; >> expr
$ matilda -d expr
b a * ;
$
```

Here is a program that features some handy-dandy option-handling code that you may use verbatim without credit: options.c
Expressions
Expressions will be composed of literals (integers, real numbers, and quoted strings), variables (tokens beginning with an alphabetic character), and operators (= + - * / % ^), plus parentheses. All tokens will be surrounded by whitespace. For example, the expression: \((x+1)\times2\); is illegal and should be written as \((x + 1) \times 2\);

A token in the input stream can be identified as follows:

- semicolons and parentheses will appear in tokens by themselves
- a real number will have a . in it
- a integer will start with a digit or a minus sign and not have a . in it
- a string will start with a double quote and end with a double quote; there may be whitespace within the string
- a variable will start with an ASCII letter (upper or lower case) and will be followed by ASCII letters or digits
- everything else is an operator

The operators have precedence in increasing order from assignment to plus to minus to times to divides to modulus to exponentiation. Parentheses override precedence. All operators are left associative:

```
$ matilda -d
5 + 3 * (4 - 2) - 1;
5 3 4 2 - * 1 - + ;
$ 
```

Conversions
An integer and a real combined together yields a real number:

```
$ matilda
3 * 123. ;
369.000000
$
```

Two strings added together results in a concatenation of the two operands:

```
$ matilda
"a b c" + "123" ;
"a b c123"
$
```

Here is a code snippet for safely concatenating two strings \(a\) and \(b\), placing the result in \(c\):

```c
char *c = malloc(sizeof(char) * (strlen(a) + strlen(b) + 1));
assert(c != 0);
sprintf(c, "%s%s", a, b);
```

A string combined with a number causes the string to be converted to a number of the same type:

```
$ matilda
3.2 * "123" ;
393.600000
$ matilda
"123.4" * 3 ;
369
$
```

Use \texttt{atoi} or \texttt{atof} to convert a string to an integer or real number, respectively.

Declarations and assignment
Variables are declared with the \texttt{var} keyword:

```
$ matilda
var x = 3 ;
x ;
3
$
```
All declarations will appear first. The initializer in a variable declaration will be a number or a string: The value of a variable may be changed via assignment:

```matilda
var x = 3;
var y;
y = (x - 1) * 4 - 2;
x + y;
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```

Variables and their values should be stored in a binary search tree for later retrieval during the processing of the postfix expression. A variable will only be declared once, so the binary search tree will contain unique keys. The specification for a binary search tree can be found here: http://beastie.cs.ua.edu/cs201/assign-bst.q.

Assignment is an operator which changes the value of a variable. The value of an assignment is the value assigned:

```matilda
var x = 1;
var y = 2;
x = y = x + y;
3
```

Only a variable can appear to the immediate left of an assignment operator.

**Reading the input**

You may find the *Art and Science of Programming - C Edition* scanner to be useful for this task:

```bash
wget troll.cs.ua.edu/ACP-C/scanner.c
wget troll.cs.ua.edu/ACP-C/scanner.h
```

You can read a token with the scanner and then examine the token to see what kind of value it is. You may not use `scanf` to read into a fixed-length character array.

**Error checking**

The only error checking you must perform is detecting the use of a variable that was not declared:

```matilda
x + 3;
variable x was not declared
```

After printing the error message on standard error, you should exit the program. Other than this one exception, your program will only be tested with valid input.

You must follow the C programming style guide for this project: http://beastie.cs.ua.edu/cs201/cstyle.html.

**Compilation details**

You must implement your calculator algorithm in portable C99. You must provide a `makefile` which responds properly to the commands:

```
make
make test
make clean
```

The `make` command compile the `matilda` executable, which should compile cleanly with no warnings or errors at the highest level of error checking (the `-Wall` and `-Wextra` options.). The `make test` command should test your program and the `make clean` command should remove object files and the executable. Here are examples (your files may differ in number and name):

```bash
$ make clean
rm -f scanner.o value.o node.o queue.o stack.o bst.o convert.o matilda.o matilda
$ make
gcc -Wall -std=c99 -c -g scanner.c
```
gcc -Wall -std=c99 -c -g value.c
gcc -Wall -std=c99 -c -g node.c
gcc -Wall -std=c99 -c -g queue.c
gcc -Wall -std=c99 -c -g stack.c
gcc -Wall -std=c99 -c -g bst.c
gcc -Wall -std=c99 -c -g convert.c
gcc -Wall -std=c99 -c -g matilda.c
gcc -Wall -std=c99 scanner.o value.o node.o queue.o stack.o bst.o convert.o matilda.o -o matilda
$ make
make: `matilda' is up to date.
$ make test
matilda -d mytestfile
a b * c + 4 1 - /
matilda mytestfile
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$

The compilation command must name the executable `matilda' (not `matilda.exe' for you Cygwin users). The You may develop on any system you wish but your program will be compiled and tested on a Linux system. Only the most foolish students would not thoroughly test their implementations on a Linux system before submission.

Documentation

All code you hand in must be attributed to its authors. Comment sparingly but well. Do explain the purpose of your program. Do not explain obvious code. If code is not obvious, consider rewriting the code rather than explaining what is going on through comments.

Grading

Grading will proceed as with assignment 0. In addition to testing your program, your binary search tree module and your matilda module will be tested individually.

Submission

To submit assignments, you need to install the submit system.

- linux, windows 10 bash, and cygwin instructions
- mac instructions

You will hand in (electronically) your code for the preliminary assessment and for final testing with the command:

    submit cs201 lusth assign1

Make sure you are in the same directory as your makefile when submitting. The submit program will bundle up all the files in your current directory and ship them to me. Thus it is very important that only the source code and any testing files be in your directory. This includes subdirectories as well since all the files in any subdirectories will also be shipped to me. I will deduct points if you submit object files or executables, so be careful. You may submit as many times as you want before the deadline; new submissions replace old submissions. Old submissions are stored and can be used for backup.