ECE 468
Problem Set 4: Symbol Tables, Declarations and Expressions

1. Write out the symbol table(s) (including any attributes that you think are important) for the following piece of code:

```
int x;
float y;
string z = "hello";

void foo() {
  int x;
  float z;
}

void main() {
  int q;
  string p = "goodbye";
}
```

Answer:

Symbol table for `GLOBAL:`

Type	**Name**	**Value**	**Offset**
int	x	—	0
float	y	—	4
string	z	"hello"	8

Symbol table for `MAIN:`

Type	**Name**	**Value**	**Offset**
int	q	—	0
string	p	"goodbye"	4

Symbol table for `FOO:`

Type	**Name**	**Value**	**Offset**
int	x	—	0
float	z	—	4

2. Explain the difference between an L-value and an R-value

Answer: An L-value is an address that can be stored to (*i.e.*, a value that can

appear on the left-hand side of an assignment statement). An R-value is an actual data value (*i.e.*, a value that can appear on the right-hand side of an assignment statement).

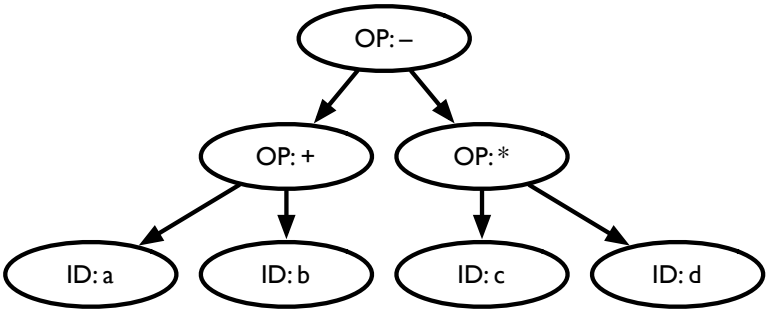
3. ECE 468 student Cam Piler has come up with a code generation strategy for his project: while walking his Abstract Syntax Tree, whenever he sees a variable, he will immediately generate code to load its value into a temporary. He thinks this will make his compiler more efficient, because he generates code as soon as possible. Is he right? Why or why not?

   Answer: This is less efficient. Recall that variables can appear on either the left or the right of an assignment statement. If a variable appears on the right-hand side, it is used as an R-value, and loading from it is the right thing to do. However, if the variable appears on the left-hand side, it is used as an L-value, and it should not be loaded from—we never actually need the value stored in the variable, we just want to store something to the address. Cam's optimization will generate a lot of useless code.

4. Give the abstract syntax tree for the following expression (assume the usual order of operations):

   ```
   (a + b) - (c * d)
   ```

   Answer:



   The generated code for this expression is:

```
LOAD(A) T1
LOAD(B) T2
+ T1 T2 T3
LOAD(C) T4
LOAD(D) T5
* T4 T5 T6
- T3 T6 T7
```

5. Consider a three-address code specification with the following instructions:

   - `LOAD(T1) T2` – load from the temporary or variable named `T1` (which must be an L-value) and place the value into `T2` (which will be an R-value).
   - `STORE(T1) T2` – store the value in temporary `T1` (which must be an R-value) into the variable `T2` (which must be an L-value).
   - `OP T1 T2 T3` – perform the operation `T3` = `T1 OP T2`, where `T1`, `T2` and `T3` are R-values, and `OP` is either `ADD`, `MUL` or `SUB`.

   Give the generated code for the expression in question 4. Also give the generated code for the following expressions. (If you create temporaries, call them `T1`, `T2`, `T3`, etc.)

   (a) `a + b + c + d`

   ```
   LOAD(A) T1
   LOAD(B) T2
   + T1 T2 T3
   LOAD(C) T4
   + T3 T4 T5
   LOAD(D) T6
   + T5 T6 T7
   ```

   (b) `(a * b) - c`

   ```
   LOAD(A) T1
   LOAD(B) T2
   * T1 T2 T3
   LOAD(C) T4
   - T3 T4 T5
   ```

   (c) `a * (b - c)`

   ```
   LOAD(A) T1
   LOAD(B) T2
   LOAD(C) T3
   - T2 T3 T4
   * T1 T4 T5
   ```