

(Hint: the internet or a textbook may be helpful here).

1. Composite types

Consider the following composite type

$$\begin{aligned}
 \text{StringExpr} &= \text{Elm string} \\
 &+ \text{Sum}(\text{StringExpr} \times \text{StringExpr}) \\
 &+ \text{Prod}(\text{StringExpr} \times \text{int}) \\
 &+ \text{Div}(\text{StringExpr} \times \text{StringExpr})
 \end{aligned}$$

For this problem, submit a single Java file (or C++ file if you are more comfortable in C++).

- (a) (5pt) Define the set of classes modeling the composite type above in Java (or C++ if you prefer).
- (b) (7pt) Write an interpret method evaluating any StringExpr to a String. The interpretation should be as the following: Sum corresponds to String concatenation. Prod concatenates the first parameter (more precisely its interpretation) a certain number of times corresponding to the second parameter which is an int. Div truncates on the left side the first string by the right side. For example, consider the following StringExpr:

```
StringExpr e = new Div(new Sum(new Elm("abc") ,new Prod(new Elm("dabc"),3)),
    new Elm("abcdabcd"))
```

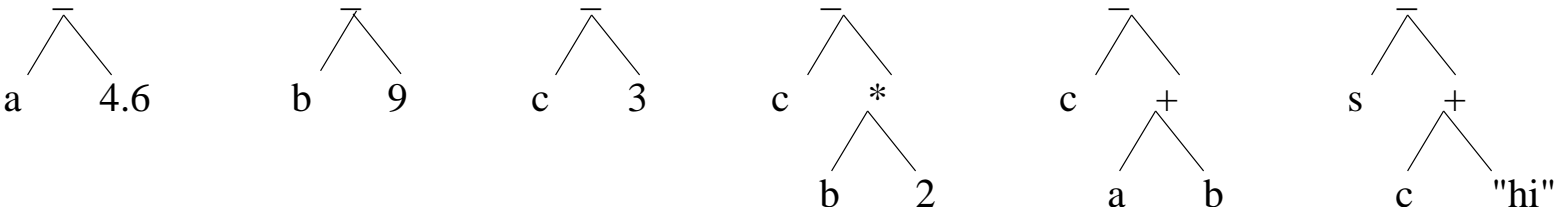
The evaluation of e.interpret() should return the String "abcdabc".

- (c) (3pt) Give another example of your own demonstrating that your implementation is correct.

2. Type inference

(5 pts each) Typecheck the following Java code using Java rules and the 4 steps. Show each step. Does it succeed or fail? I'm including each line as a tree in case it helps.

```
double a = 4.6;
int b = 9;
int c = 3;
c = b * 2;
c = a + b;
String s = c + "hi";
```



3. Type checking

- (a) (5pt) What is type checking good for? (one reason)
- (b) (5pt) C does all typechecking at compile time (its a statically typed language). (You can find a copy of hello world in C in the student files for this course.)
 What would happen to a C program if all the type checking was done at run time instead of compile time? Speed? Would all currently good programs still run? Would any currently bad programs now run happily (that didnt run before)?
- (c) (5pt) When does Java do type checking? give some examples of things that are typechecked during compilation/running.