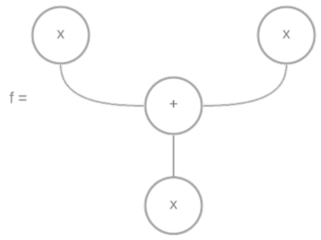
PLPDI Compilers: Assignment 2

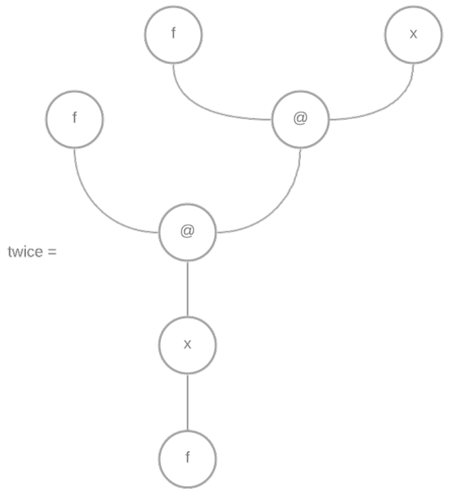
Question A

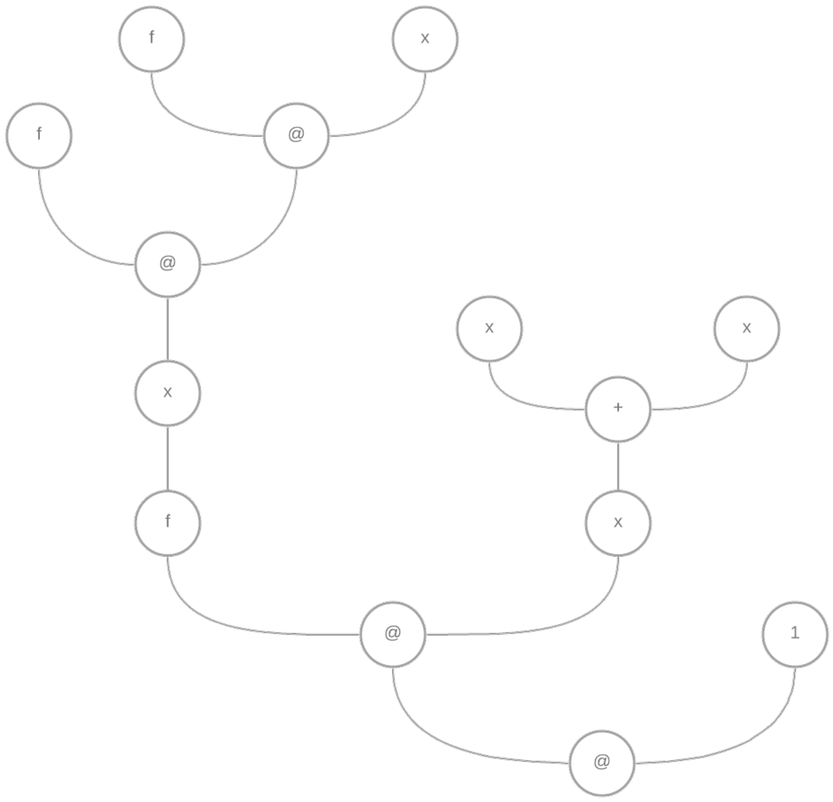
```
func f x = x + x
func twice f x = f(f(x))
twice f 1
```

1. Draw the AST

Note: Variable (named) root nodes represent parameters







twice f 1

2. Draw the ASG

I created the ASG of this program using the online ASG-based abstraction machine.

The following *SPARTAN* statement:

```
bind f = LAMBDA(;x. PLUS(x,x)) in
bind twice = LAMBDA(; f. LAMBDA(; x. APP(f,APP(f,x))))
in
APP(APP(twice,f),1)
```

Created the following ASG:

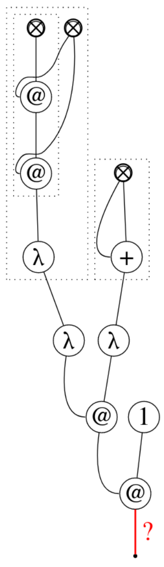
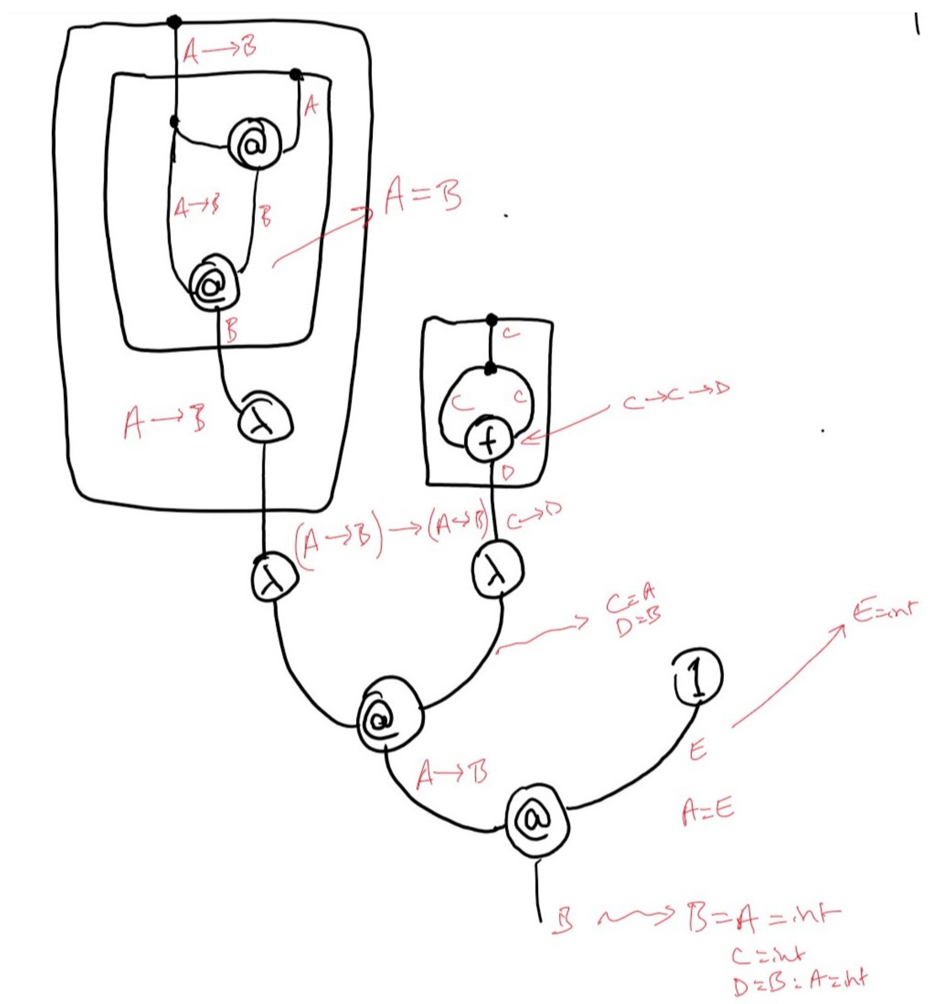


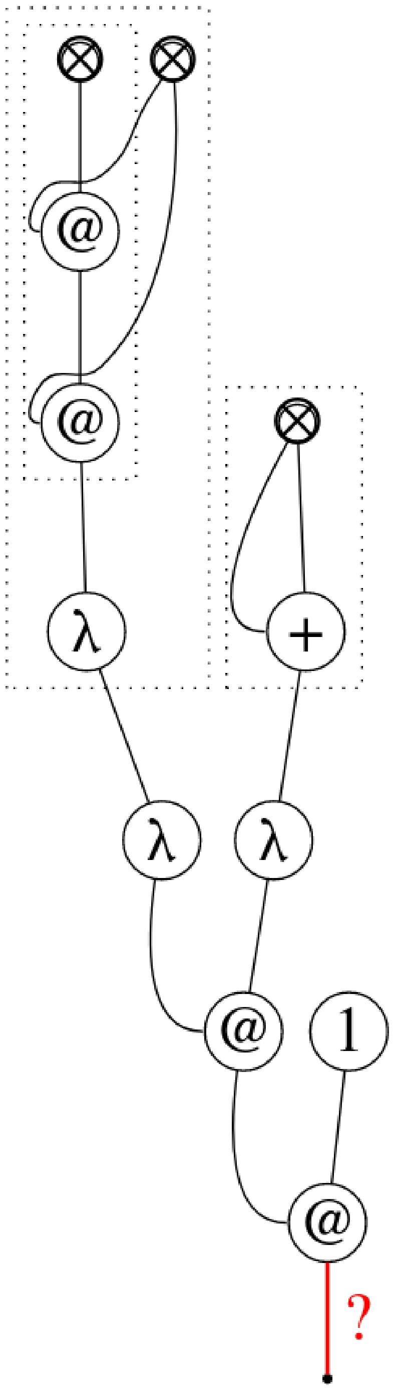
Figure 1: Initial ASG

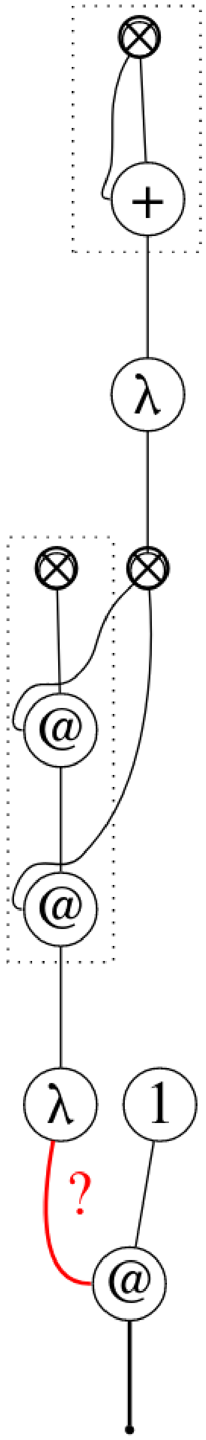
3. Perform type inference on this program

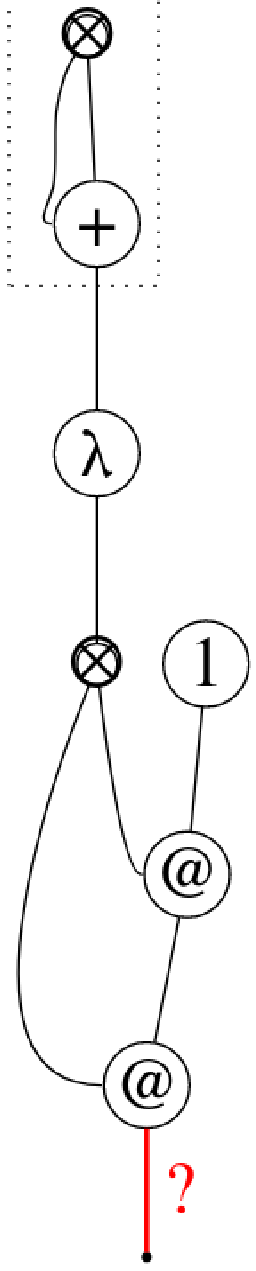


4. Draw the intermediate ASGs in the evaluation of this program

Note Diagrams read from left to right on the page







⊗
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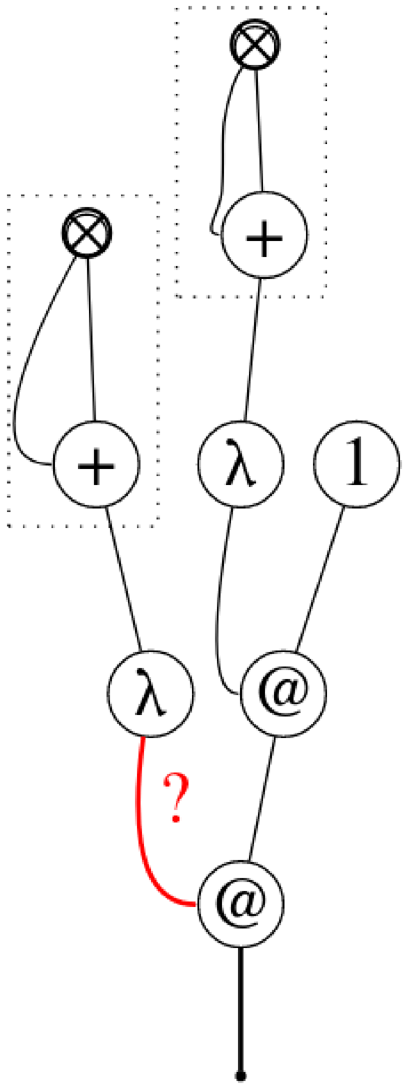
?



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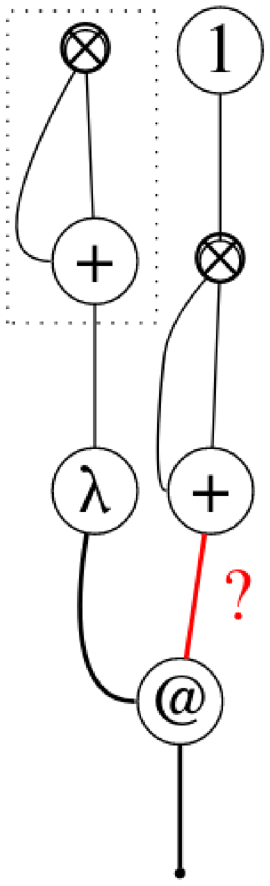

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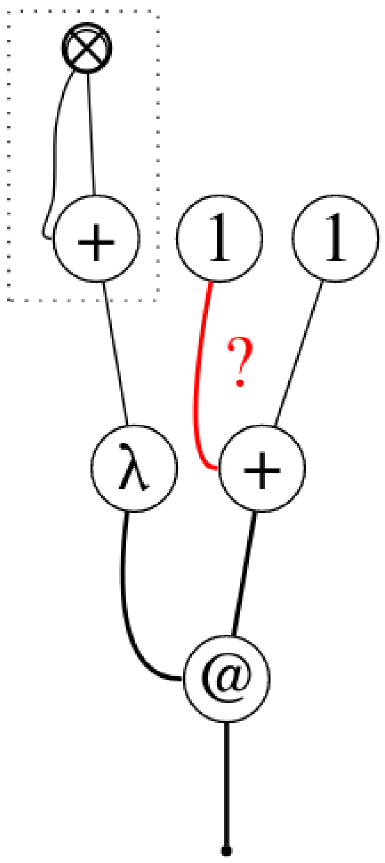

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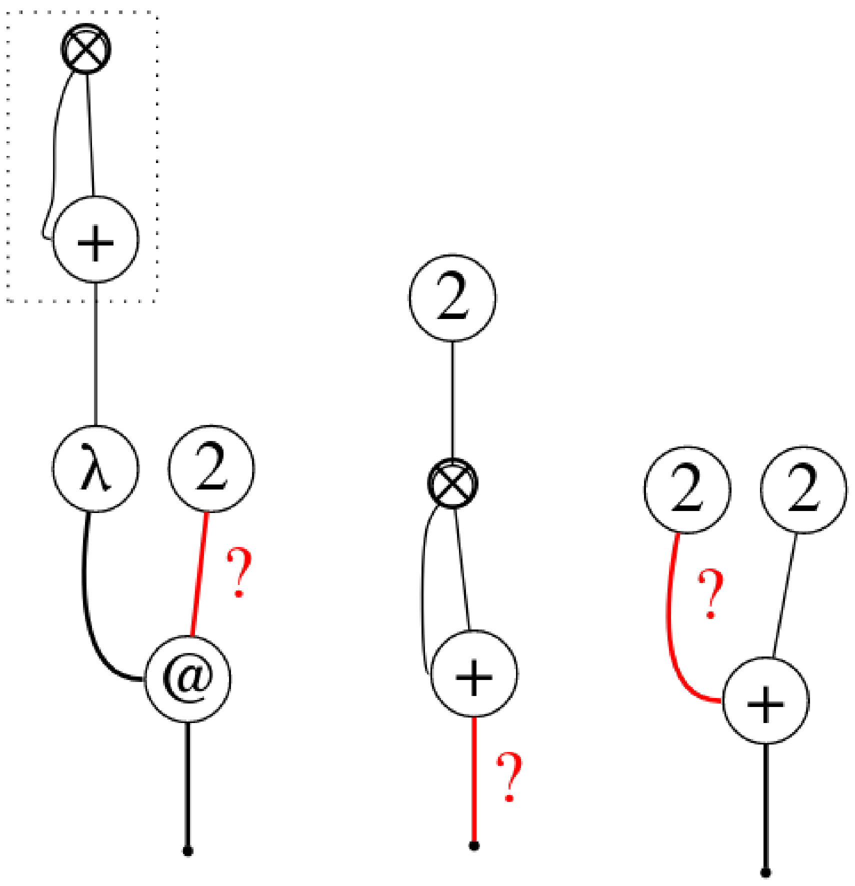
⊗
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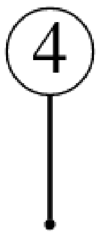
2
?
+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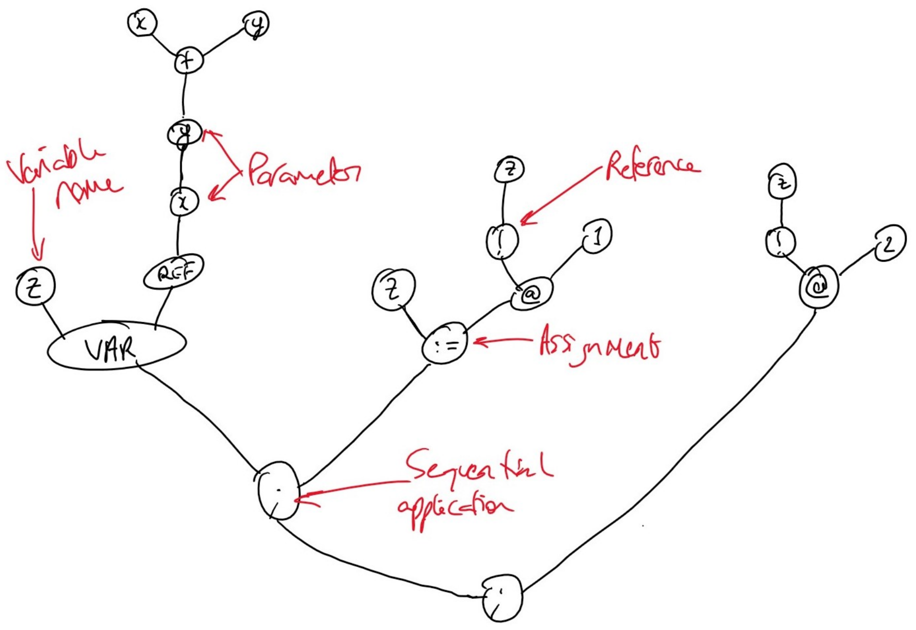
Question B

```
var z = ref(func x y -> x + y)
z := (!z)(1)
(!z)(2)
```

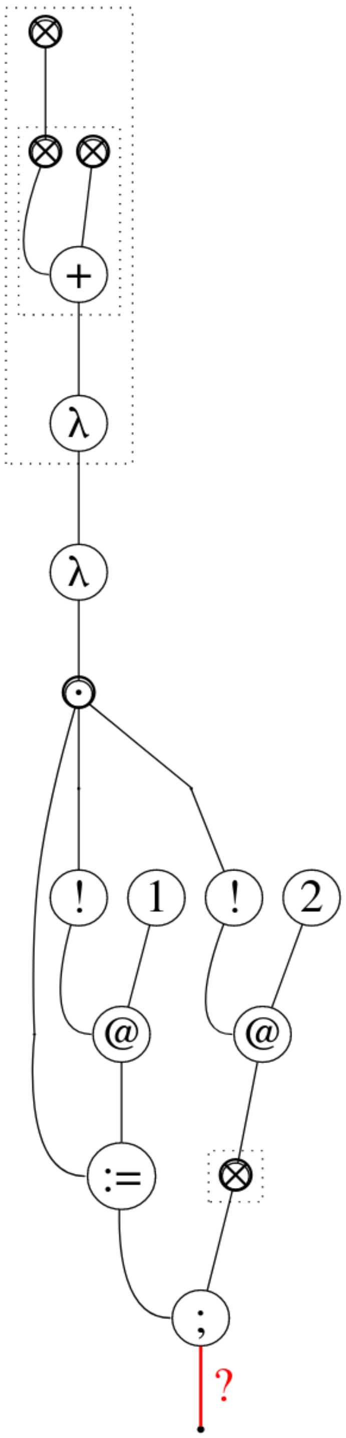
1. Draw the AST of this program



2. Draw the ASG of this program

This ASG was created using the SPARTAN visualiser with the code:

```
new z = LAMBDA(;x. LAMBDA(;y.  PLUS(x,y))) in
bind a = ASSIGN(z,APP(DEREF(z),1)) in
bind b = APP(DEREF(z),2) in
SEC(a;b)
```



⊗
⊗
⊗
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λ
⊙
!
1
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2
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:=
⊗
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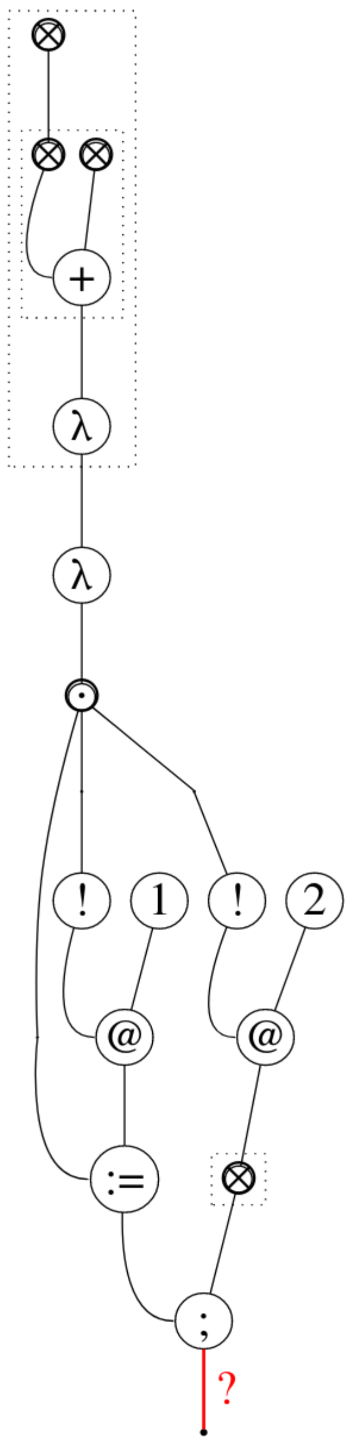
?

3. Draw the intermediate ASGs in the evaluation of this program

Note Diagrams read from left to right on the page



⊗
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! 1 ! 2
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:= ⊗
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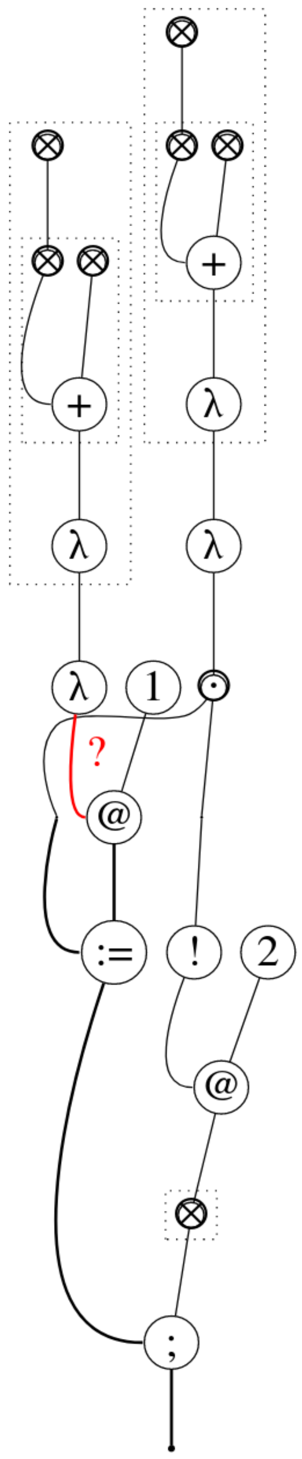
?



⊗ ⊗ ⊗
⊗ ⊗ +
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λ 1 ⊙
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:= ! 2
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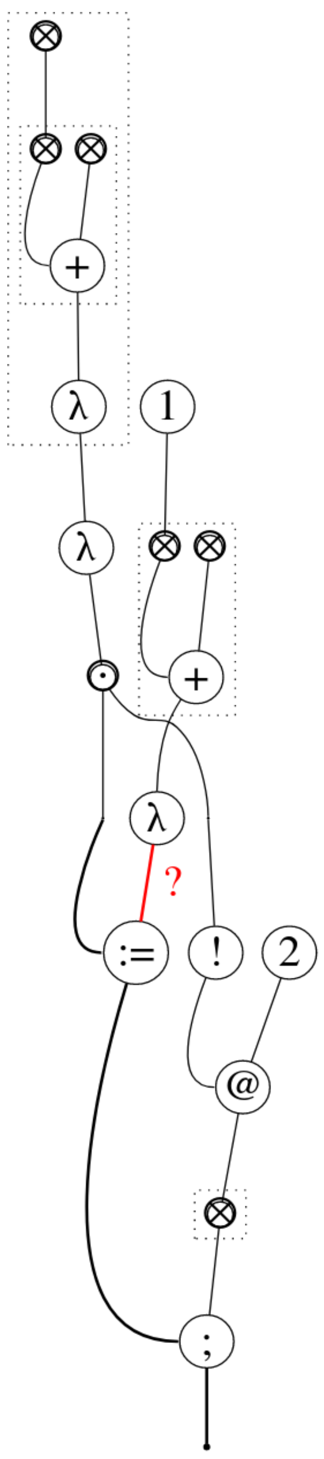
λ
1
λ
+
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?
:=
!
2
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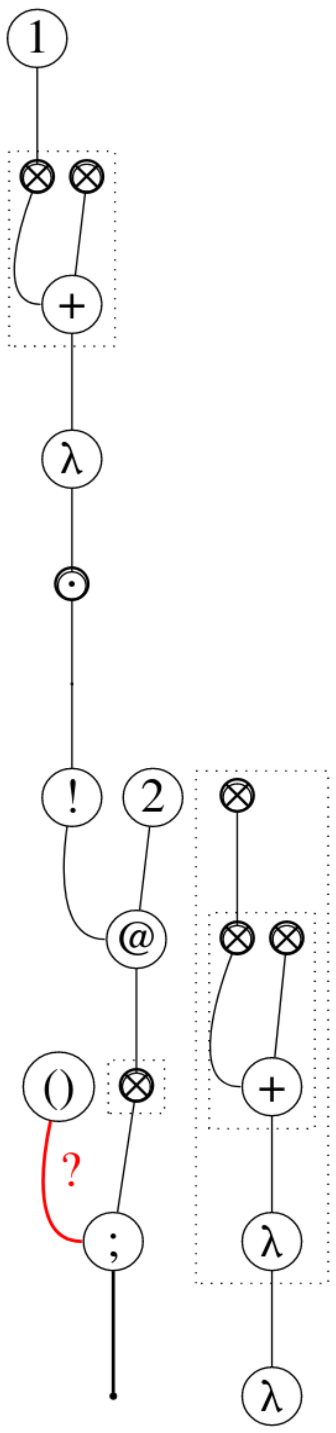
;


1
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λ
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2
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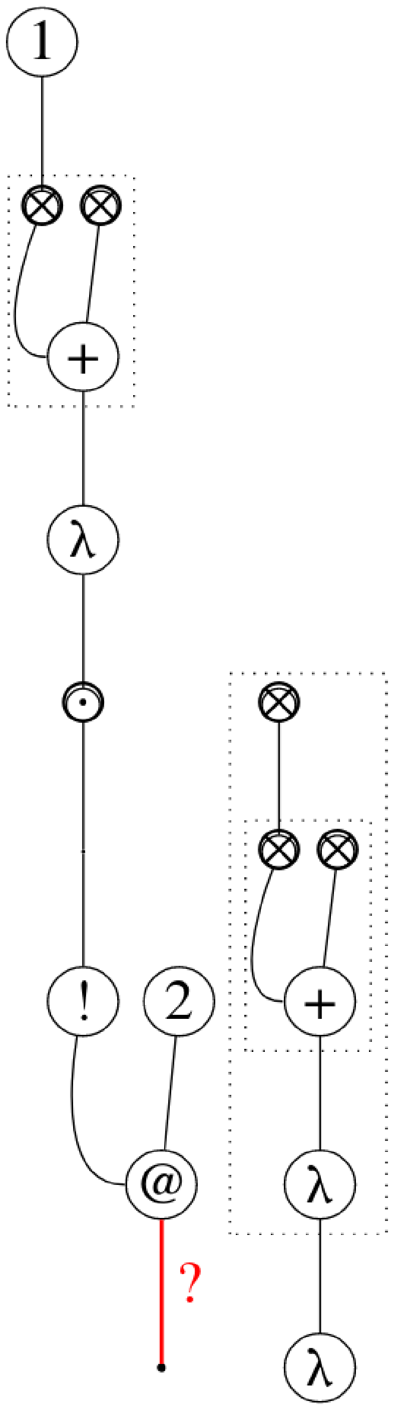
()
?
;
+
λ
λ


1
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λ
!
2
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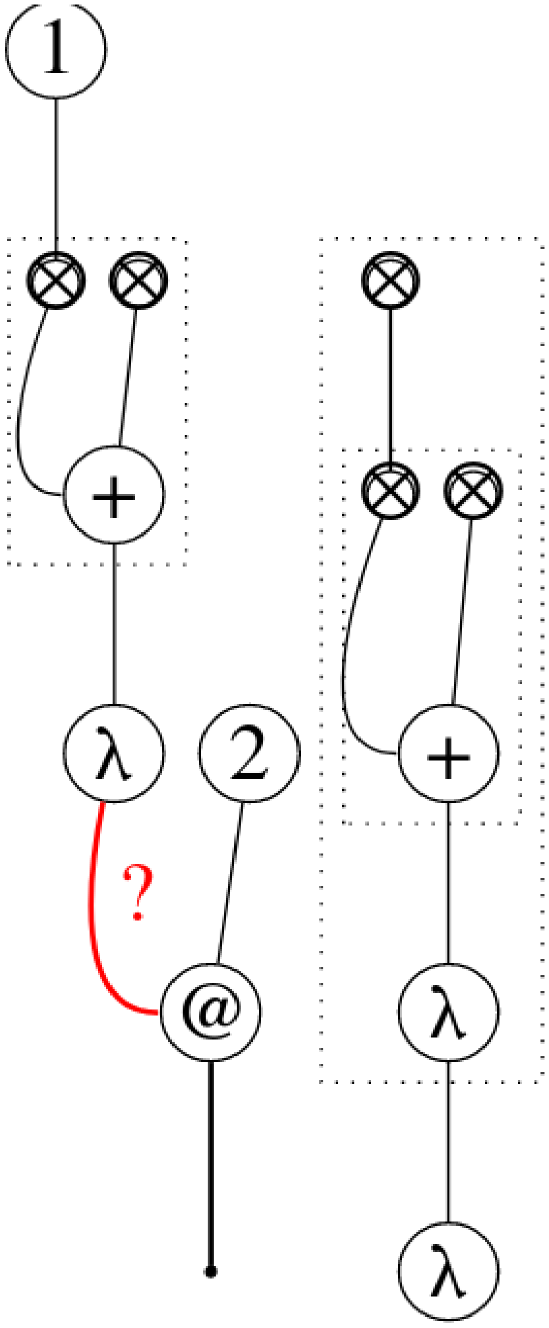
?
+
λ
λ


1
+
λ
2
?
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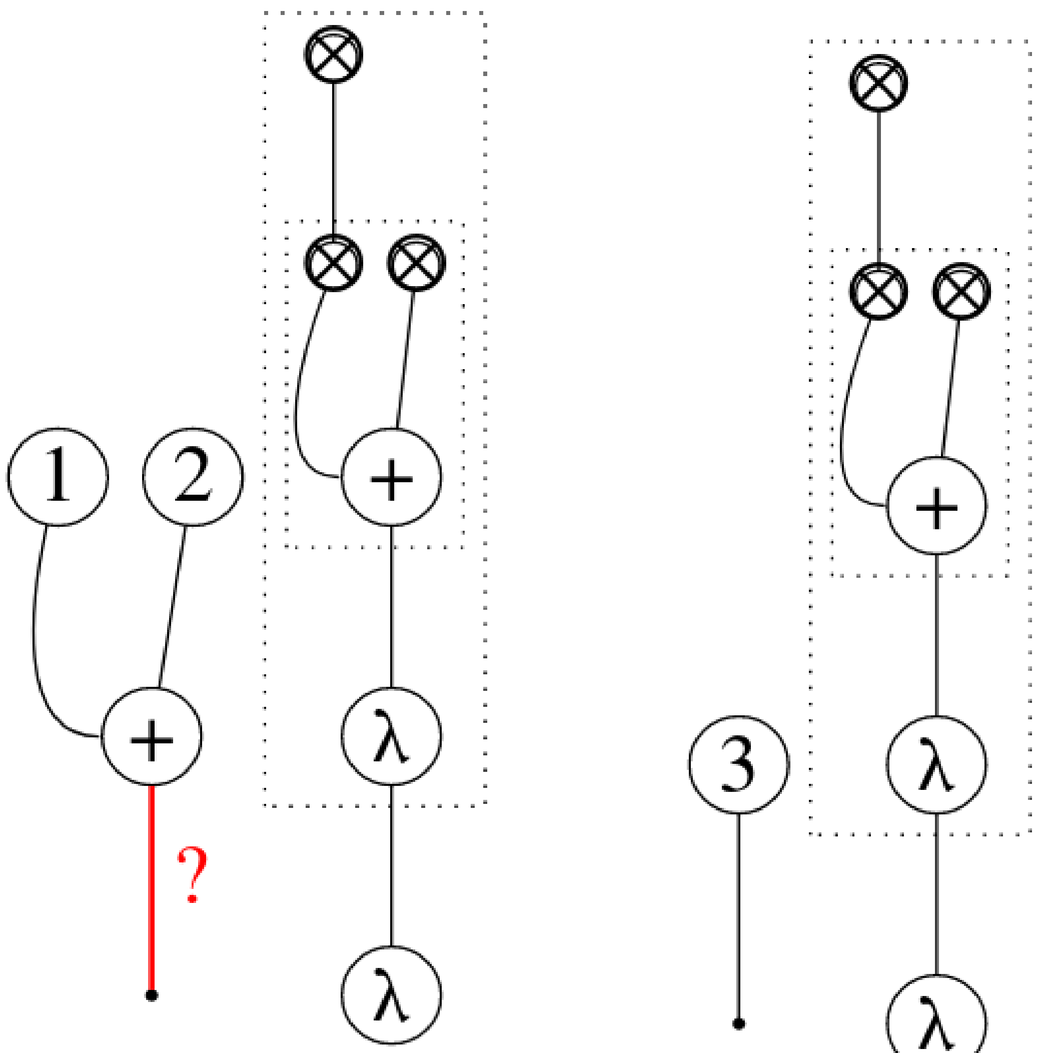
+
λ
λ


1
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+
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⊗
⊗
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+
λ
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3
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⊗
+
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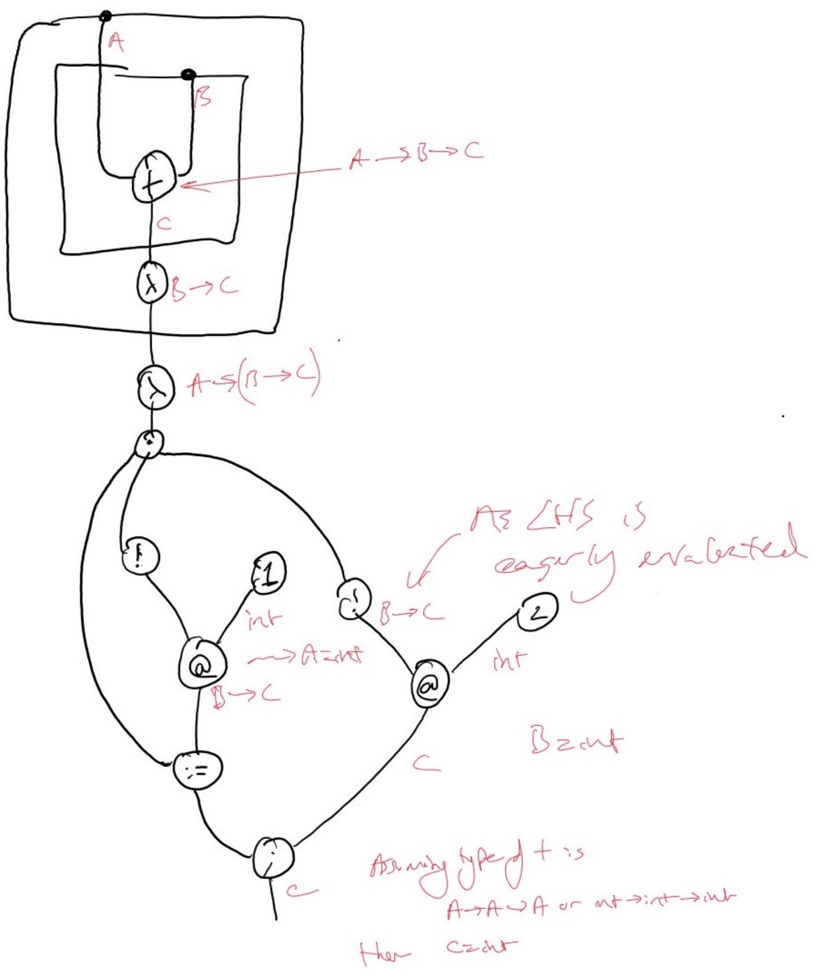
4. Perform type inference on this program



As LHS is eagerly evaluated

B = int

Assuming type of + is A → A → A or int → int → int then C = int

Static Vs Dynamic Typing

In statically typed languages, such as C or Rust, one is required to specify the type of any variable, function parameter or return argument explicitly. In dynamically typed languages, such as Python, a variable or method can be said to have `Any` type. This allows for less verbose, more flexible code. Dynamic typing in and of itself does not lead to runtime errors, instead it makes it much easier for a programmer to accidentally cause them.

For example, in python you could define a function:

```
f = lambda x,y: x**y
```

And call it with:

```
f(2,"foo")
```

leading to a runtime error

Whereas, in Rust, a dynamically typed language (that does not attempt to cast explicitly defined variables), The compilation fails as it expects an `i32` not a `str`

```
fn f(x:i32, y:i32) -> i32 {
    x^y
}

fn main() {
    f(1,"foo");
        ^^^^^ expected `i32`, found `&str`
}
```

In the context of this example, we are assuming the type of `+`. If instead the operator had the type `str -> str -> str` the program would fail at runtime as we attempted to pass integers. If the compiler knew the type of `+`, i.e. in our graph `+` was already labelled `str -> str -> str` then our type inference for the rest of the program would fail, leading to a compilation error rather than a runtime error.