Lightning Review: Types of Expressions

**Primitive expressions:**
- Number
- Name
- String

**Call expressions:**
- `max (2, 3)`
- `max (min (pow (3, 5), -4), min (1, -2))`
- One big nested call expression
- `max (min (pow (3, 5), -4), min (1, -2))`

Lightning Review: Expression Trees

The Print Function

(Demo)

Pure Functions & Non-Pure Functions

**Pure Functions**
- `abs (number)`
  - Argument
  - Return value
  - Only produces return values

**Non-Pure Functions**
- `print (number)`
  - Argument
  - Returns None!
  - Side effect
  - Python displays the output “-2”

The Interactive interpreter displays all return values except None.

Nested Expressions with Print

None, None → `print (...)`: None

- `>>> print (print (1), print (2))`
  - None
  - None
  - None
  - None

1, 100 → `pow(x, y)`:

- 12676506002282294014967803285376

2, 100 → `pow (x, y)`:

- 12676506002282294014967803285376

1, 2 → `print (...)`: None

- `>>> print (print (1), print (2))`
  - None
  - None
  - None
  - None

2, 2 → `print (...)`: None

- `>>> print (print (1), print (2))`
  - None
  - None
  - None
  - None
The Elements of Programming

- Primitive Expressions and Statements
  - The simplest building blocks of a language

- Means of Combination
  - Compound elements are built from simpler ones

- Means of Abstraction
  - Compound elements can be named and manipulated as units

Environment Diagrams

Environment diagrams visualize the interpreter's process.

- Import statement
- Assignment statement

Code (left):
- Statements and expressions
- Next line is highlighted

Frames (right):
- A name is bound to a value
- In a frame, there is at most one binding per name

Example: [http://goo.gl/sQabt](http://goo.gl/sQabt)

User-Defined Functions

Named values are a simple means of abstraction

Named expressions are a more powerful means of abstraction

Function “signature” indicates how many parameters

Function “body” defines a computational process

Execution procedure for def statements:
1. Create a function value with signature
   `<name> (<formal parameters>);`
2. Bind `<name>` to that value in the current frame

Calling User-Defined Functions

Procedure for applying user-defined functions (version 1):
1. Add a local frame
2. Bind formal parameters to arguments in that frame
3. Execute the body of the function in the new environment

Example: [http://goo.gl/OapJa](http://goo.gl/OapJa)
Looking Up Names in Environments

Every expression is evaluated in the context of an environment. So far, the current environment is either:
• The global frame alone, or
• A local frame, followed by the global frame.

**Most important two things I’ll say all day:**
An environment is a sequence of frames.
A name evaluates to the value bound to that name in the earliest frame of the current environment in which that name is found.

E.g., to look up some name in the body of the square function:
• Look up the name in the local frame.
• If not found, look it up in the global frame. (Built-in names like “print” are in the global frame too, but we don’t draw them in environment diagrams.)

Formal Parameters

```
def square(x):
    return mul(x, x)
```

```
def square(y):
    return mul(y, y)
```

Formal parameters have local scope

Examples: [http://goo.gl/OapJa](http://goo.gl/OapJa)