New 3D printer shapes objects with rays of light

www.sciencedaily.com/releases/2019/01/190131143330.htm

https://youtu.be/jcwYFBeetH0

"A new 3D printer uses light to transform gooey liquids into complex solid objects in only a matter of minutes. The printer can create objects that are smoother, more flexible and more complex than what is possible with traditional 3D-printers. It can also encase an already existing object with new materials, which current printers struggle to do."

Announcements

Homework 2 is released and is due Friday 2/8 @ 11:59pm.

Hog has been released! Entire project due Thursday 2/7

- You can work with a partner on Phases 2 & 3.
- Submit everything by Wednesday 2/6 for an early submission bonus point.

Midterm 1

- HKN Review Session Saturday 2/9 12-3 PM in HP Auditorium
- CSM Review Session Sunday 2/10 2-4 PM in GPB100
- Exam will take place Monday 2/11 7-8pm

Abstraction

Functional Abstractions

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

```
def sum_squares(x, y):
    return square(x) + square(y)
```

What does sum_squares need to know about square?

• Square takes one argument.	Yes
• Square has the intrinsic name square.	No
• Square computes the square of a number.	Yes
• Square computes the square by calling mul.	No

```
def square(x):
    return pow(x, 2)
```

```
def square(x):
    return mul(x, x-1) + x
```

If the name "square" were bound to a built-in function, sum_squares would still work identically.

Choosing Names

Names typically don’t matter for correctness

but

they matter a lot for composition

From:	**To:**
`true_false`	`rolled_a_one`
`d`	`dice`
`helper`	`take_turn`
`my_int`	`num_rolls`
`l, I, O`	`k, i, m`

Names should convey the meaning or purpose of the values to which they are bound.

The type of value bound to the name is best documented in a function's docstring.

Function names typically convey their effect (**print**), their behavior (**triple**), or the value returned (**abs**).

Which Values Deserve a Name

Reasons to add a new name

Repeated compound expressions:

```
if sqrt(square(a) + square(b)) > 1:
    x = x + sqrt(square(a) + square(b))
```

```
hypotenuse = sqrt(square(a) + square(b))
if hypotenuse > 1:
    x = x + hypotenuse
```

Meaningful parts of complex expressions:

```
x1 = (-b + sqrt(square(b) - 4 * a * c)) / (2 * a)
```

```
discriminant = square(b) - 4 * a * c
x1 = (-b + sqrt(discriminant)) / (2 * a)
```

PRACTICAL GUIDELINES

More Naming Tips

- Names can be long if they help document your code:

```
average_age = average(age, students)
```

  is preferable to

```
# Compute average age of students
aa = avg(a, st)
```

- Names can be short if they represent generic quantities: counts, arbitrary functions, arguments to mathematical operations, etc.

```
n, k, i - Usually integers
x, y, z - Usually real numbers
f, g, h - Usually functions
```

Testing

Test-Driven Development

Write the test of a function before you write the function.

A test will clarify the domain, range, & behavior of a function.

Tests can help identify tricky edge cases.

Develop incrementally and test each piece before moving on.

You can't depend upon code that hasn't been tested.

Run your old tests again after you make new changes.

Bonus idea: Run your code interactively.

Don't be afraid to experiment with a function after you write it.

Interactive sessions can become doctests. Just copy and paste.

(Demo1)

Currying

Function Currying

```
def make_adder(n):
    return lambda k: n + k
```

```
>>> make_adder(2)(3)
5
>>> add(2, 3)
5
```

There's a general relationship between these functions

(Demo2)

Curry: Transform a multi-argument function into a single-argument, higher-order function

Decorators

Function Decorators

(Demo3)

Function decorator

```
@trace1
def triple(x):
    return 3 * x
```

Decorated function

is identical to

Why not just use this?

```
def triple(x):
    return 3 * x
triple = trace1(triple)
```

Review

What Would Python Display?

The print function returns None. It also displays its arguments (separated by spaces) when it is called.

```
from operator import add, mul
def square(x):
    return mul(x, x)
```

A function that takes any argument and returns a function that returns that arg

```
def delay(arg):
    print('delayed')
    def g():
        return arg
    return g
```

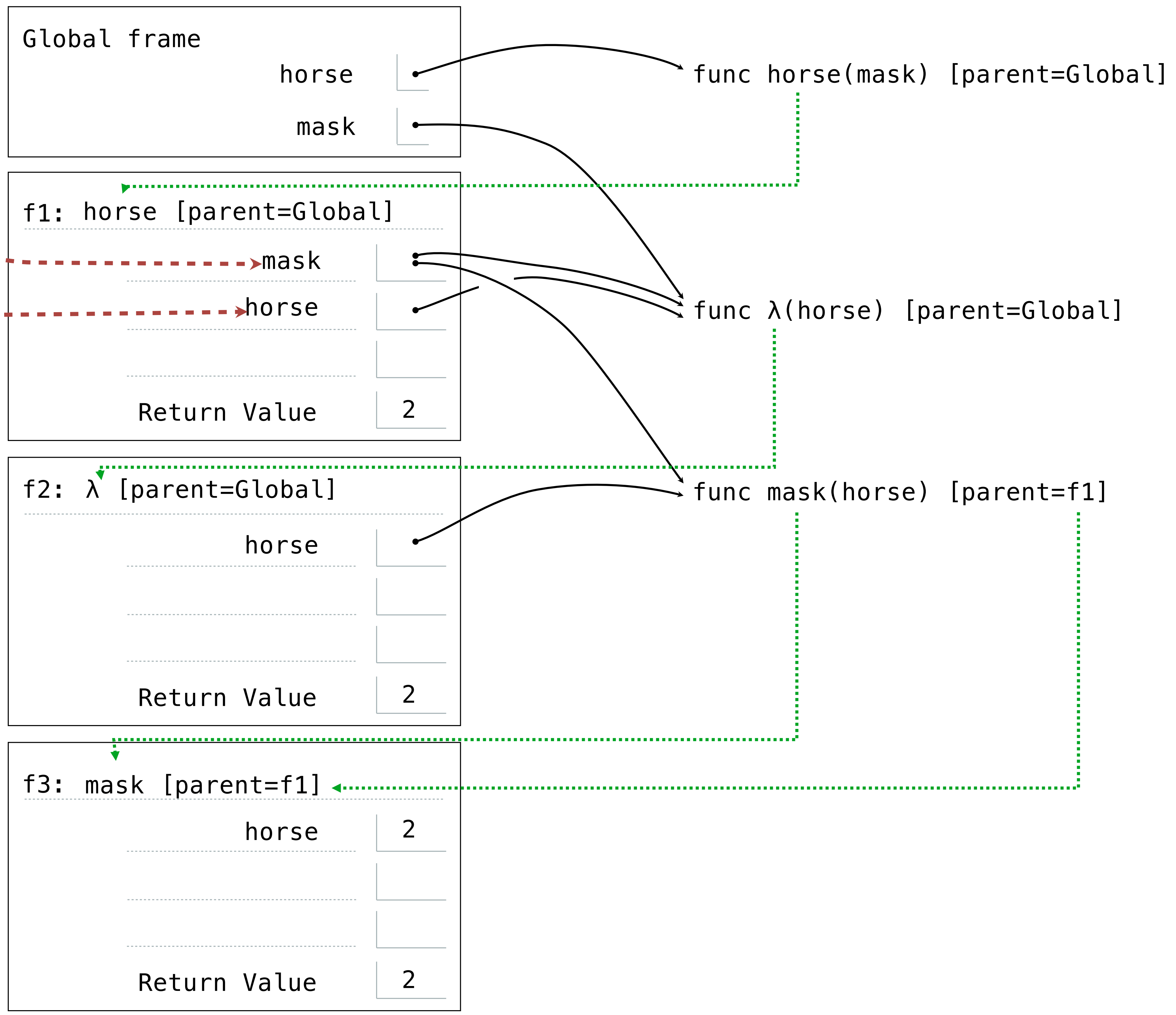
Names in nested def statements can refer to their enclosing scope

This expression	Evaluates to	Interactive Output
`5`	5	5
`print(5)`	None	5
`print(print(5))` (inner `print(5)`: None)	None	5 None
`delay(delay)()(6)()`	6	delayed delayed 6
`print(delay(print)()(4))`	None	delayed 4 None

```
def horse(mask):
    horse = mask
    def mask(horse):
        return horse
    return horse(mask)

mask = lambda horse: horse(2)

horse(mask)
```



Global frame
horse
mask
func horse(mask) [parent=Global]
f1: horse [parent=Global]
mask
horse
Return Value
2
func λ(horse) [parent=Global]
f2: λ [parent=Global]
horse
Return Value
2
func mask(horse) [parent=f1]
f3: mask [parent=f1]
horse
2
Return Value
2