# 61A Lecture 9

Friday, September 19

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- Optional Hog strategy contest concludes Wednesday 2/18 @ 11:59pm

# Abstraction

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

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x, y, z - Usually real numbers
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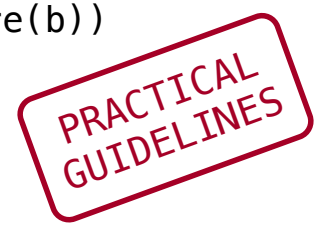


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(Demo)

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@trace1
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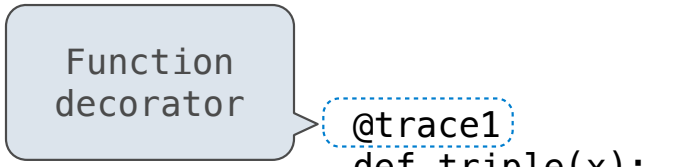


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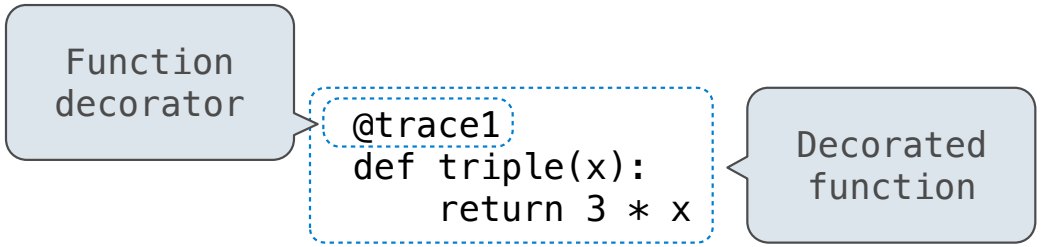

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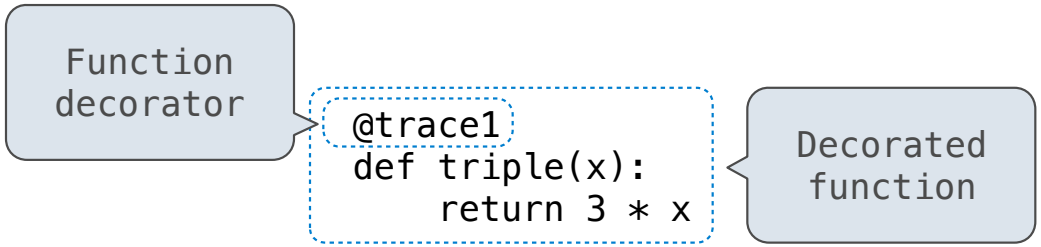


*is identical to*

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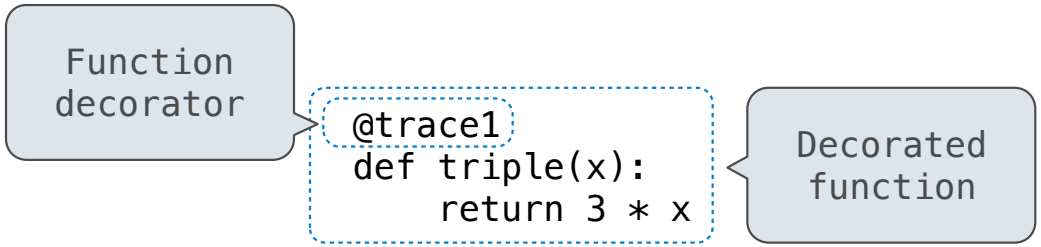


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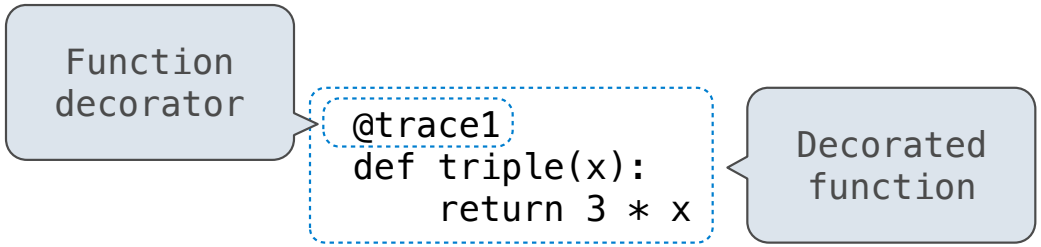


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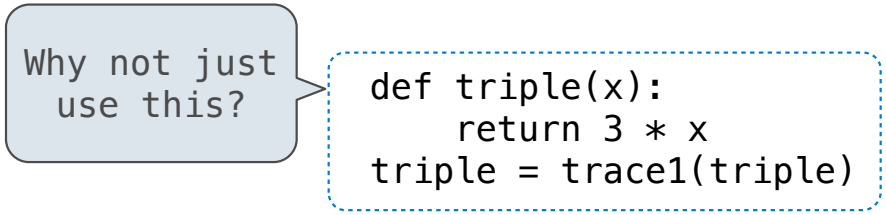

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>>> add(2, 3)
5
```

There's a general relationship between these functions

(Demo)

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

# Review

# What Would Python Print?

# What Would Python Print?

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

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None

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```
def delay(arg):
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|---|---|---|
| `5` | `5` | `5` |
| `print(5)` | `None` | `5` |
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`print(print(5))` → `None`

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`delay(delay)()(6)()`

Names in nested def statements can refer to their enclosing scope

# What Would Python Print?

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):
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| This expression | Evaluates to | Interactive Output |
|---|---|---|
| `5` | `5` | `5` |
| `print(5)` | `None` | `5` |
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`print(5)` → None

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| `5` | `5` | `5` |
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| `print(print(5))` | `None` | `5`<br>`None` |
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| `print(print(5))` | `None` | `5`<br>`None` |
| `delay(delay)()(6)()` | `6` | `delayed`<br>`delayed`<br>`6` |
| `print(delay(print)()(4))` | | |

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| `print(print(5))` | `None` | `5`<br>`None` |
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| `5` | `5` | `5` |
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| `print(print(5))` | `None` | `5`<br>`None` |
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| `print(print(5))` | `None` | `5`<br>`None` |
| `delay(delay)()(6)()` | `6` | `delayed`<br>`delayed`<br>`6` |
| `print(delay(print)()(4))` | | `delayed`<br>`4`<br>`None` |

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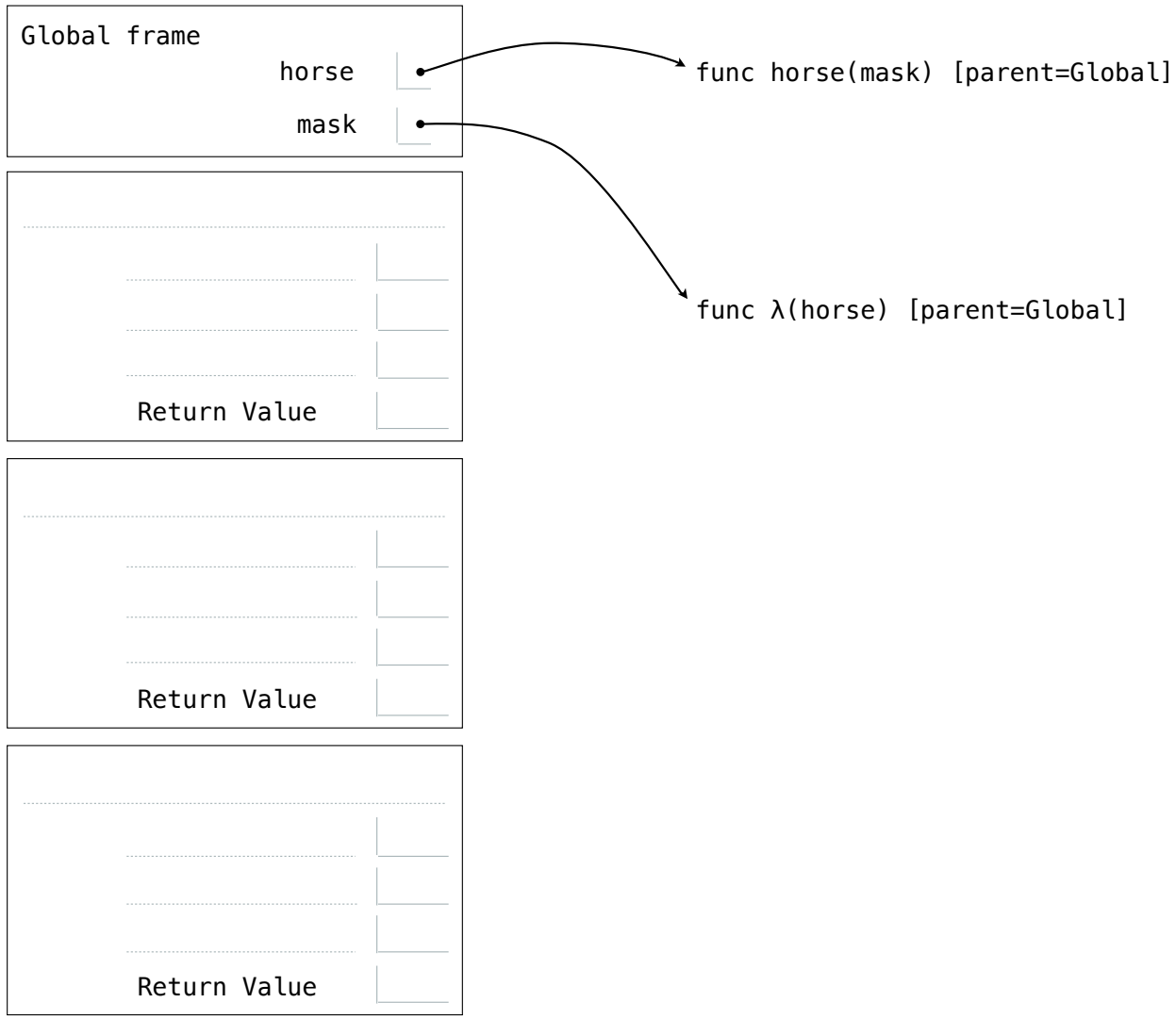
| `delay(delay)()(6)()` | `6` | `delayed`<br>`delayed`<br>`6` |
| `print(delay(print)()(4))` | `None` | `delayed`<br>`4`<br>`None` |

None

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

mask = lambda horse: horse(2)

horse(mask)
```



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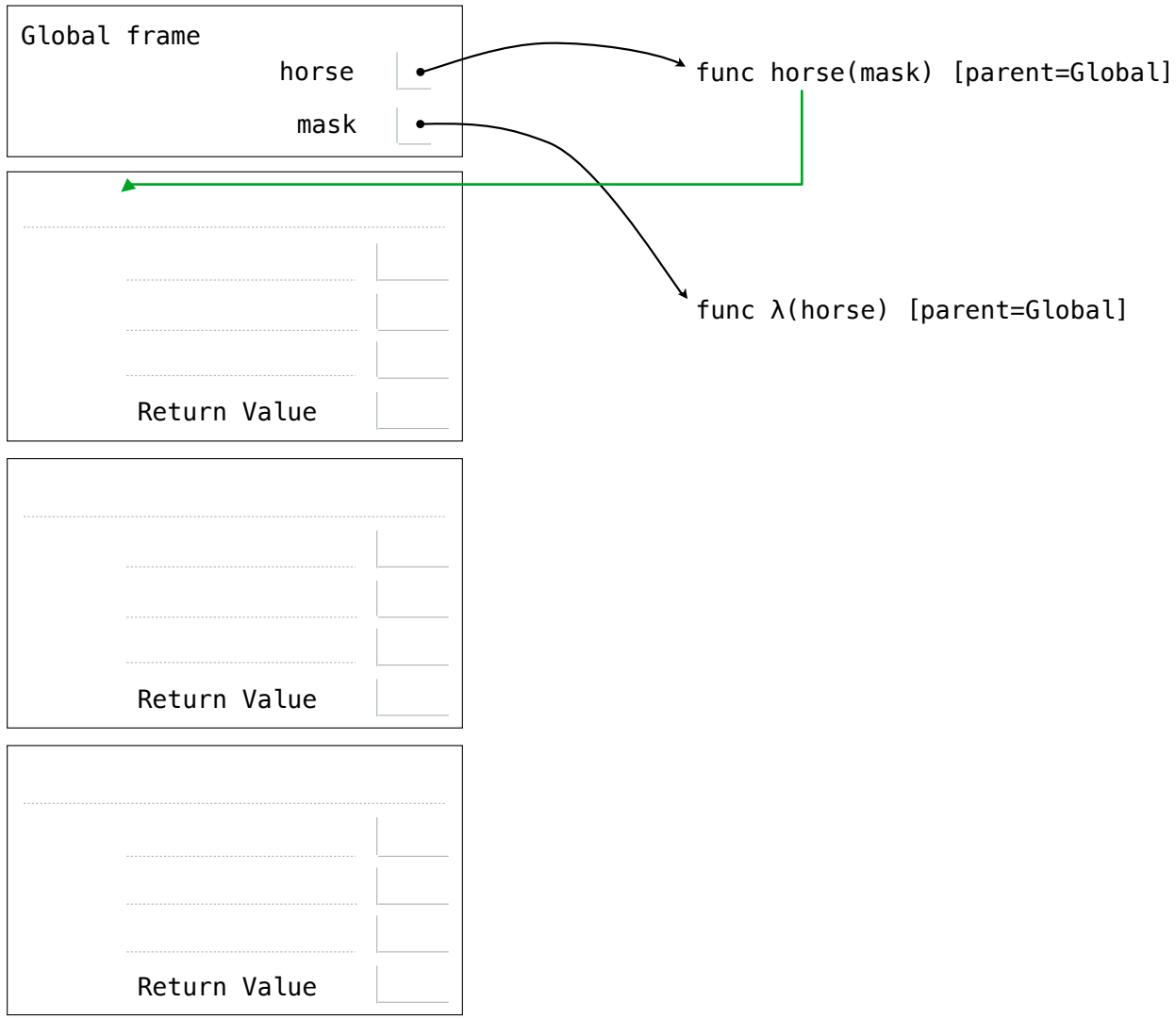

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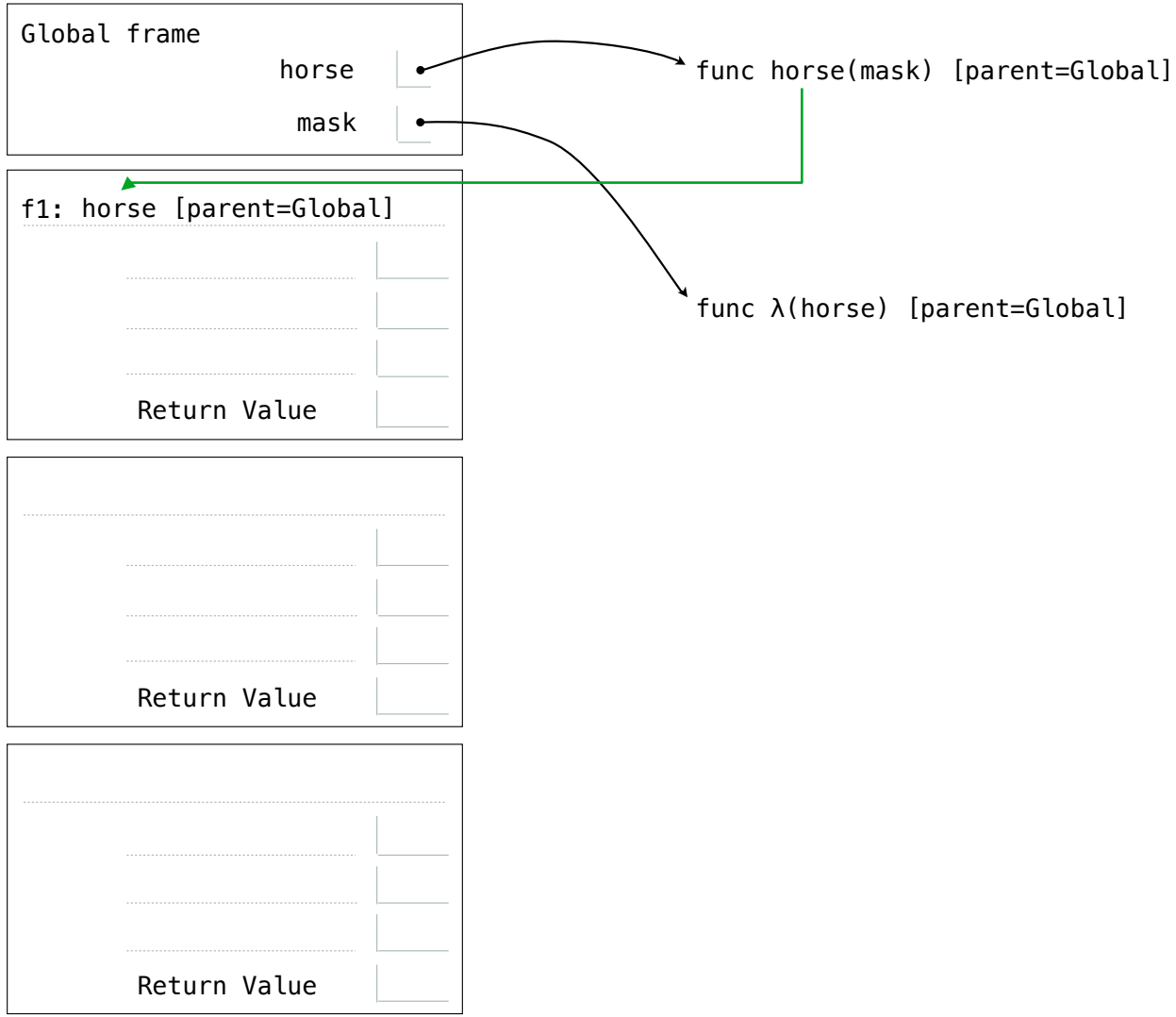

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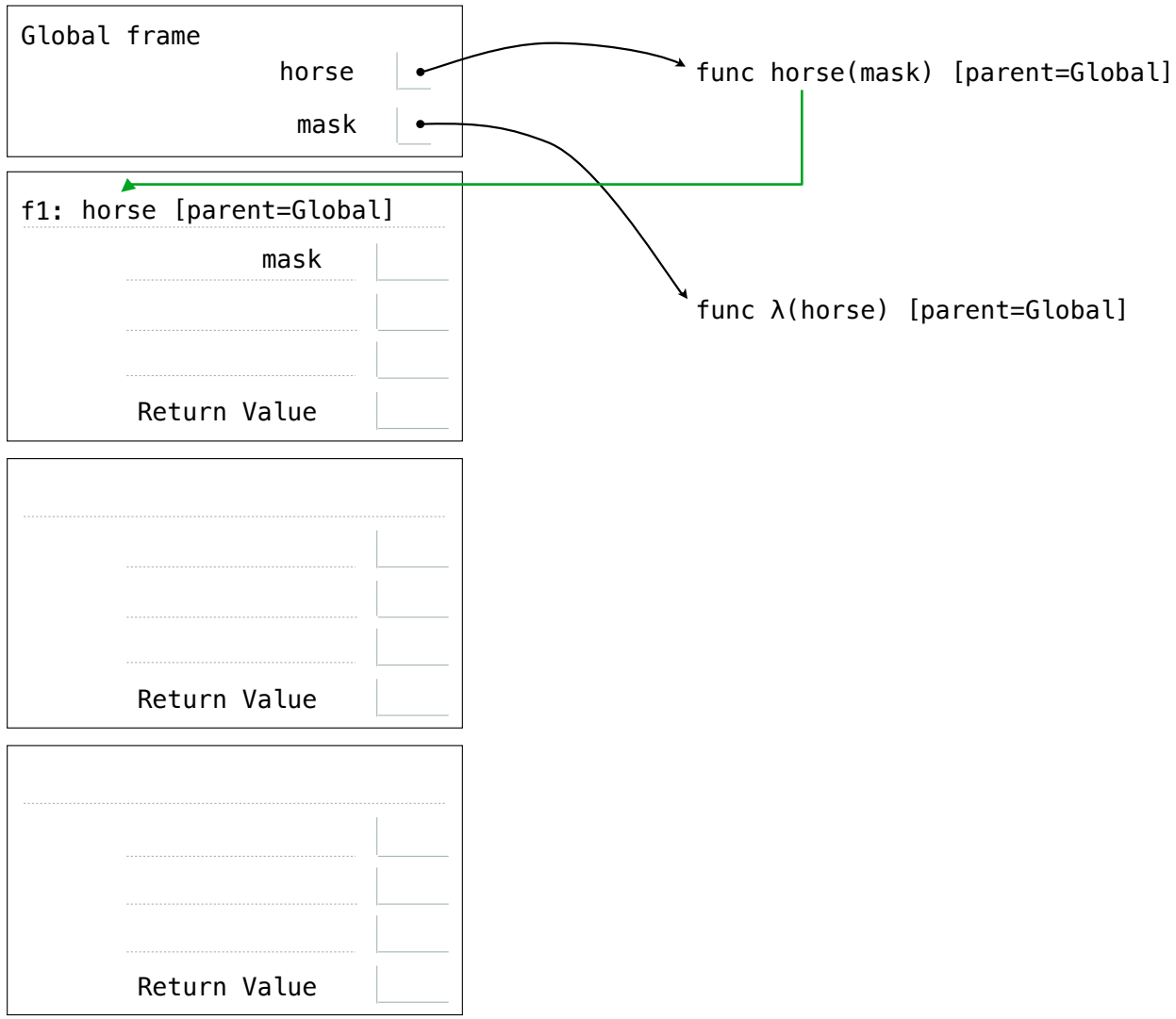

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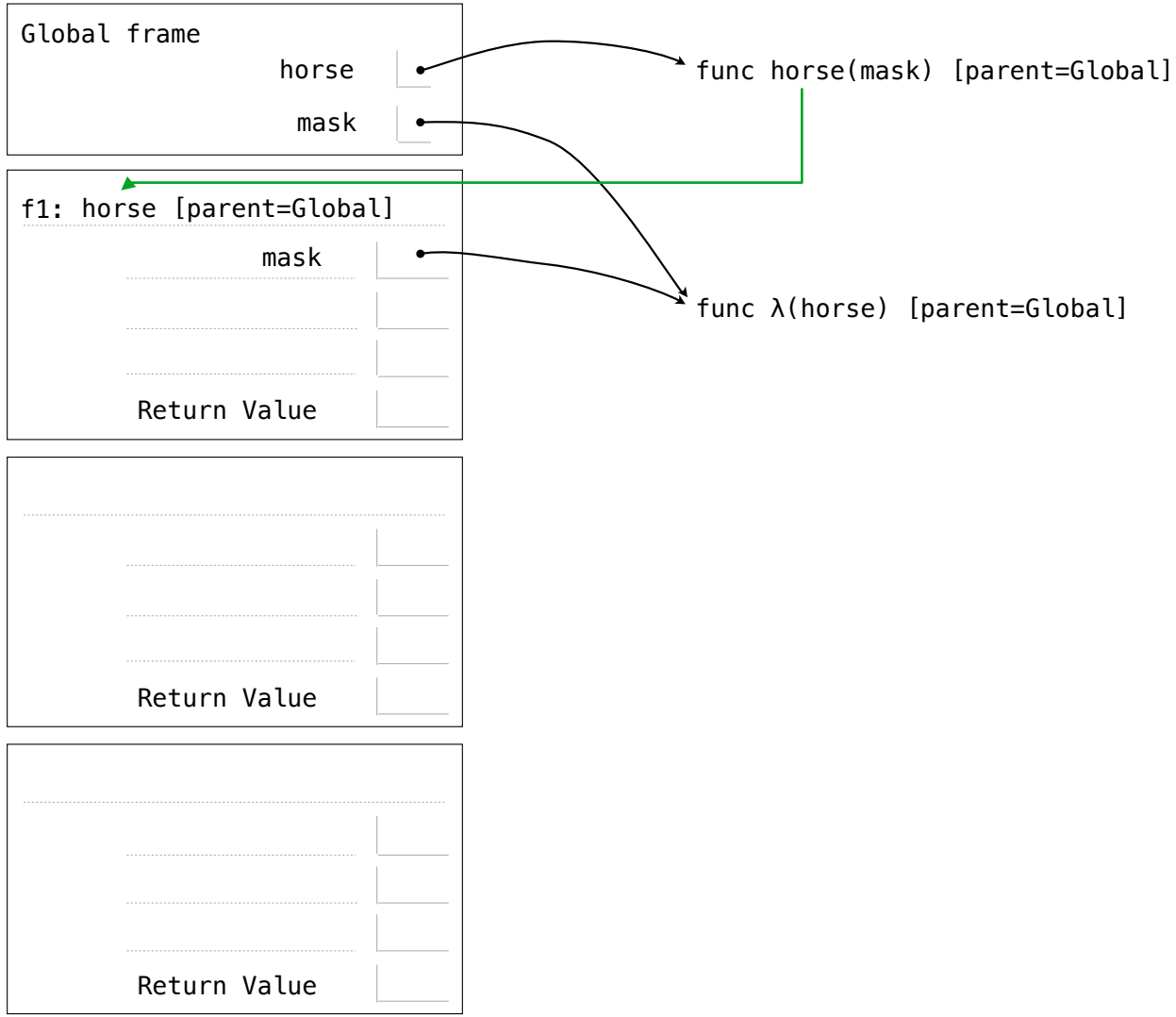

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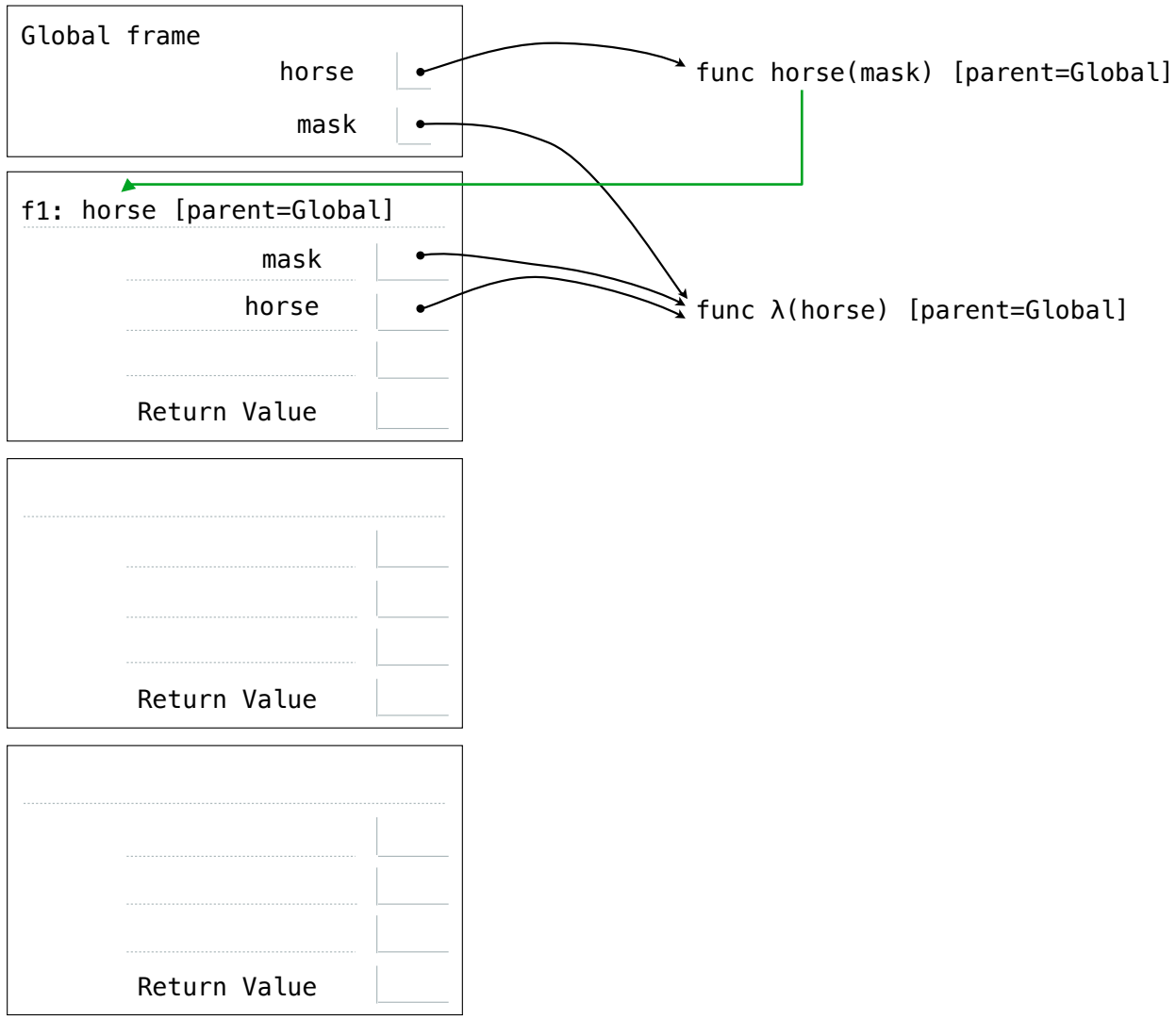

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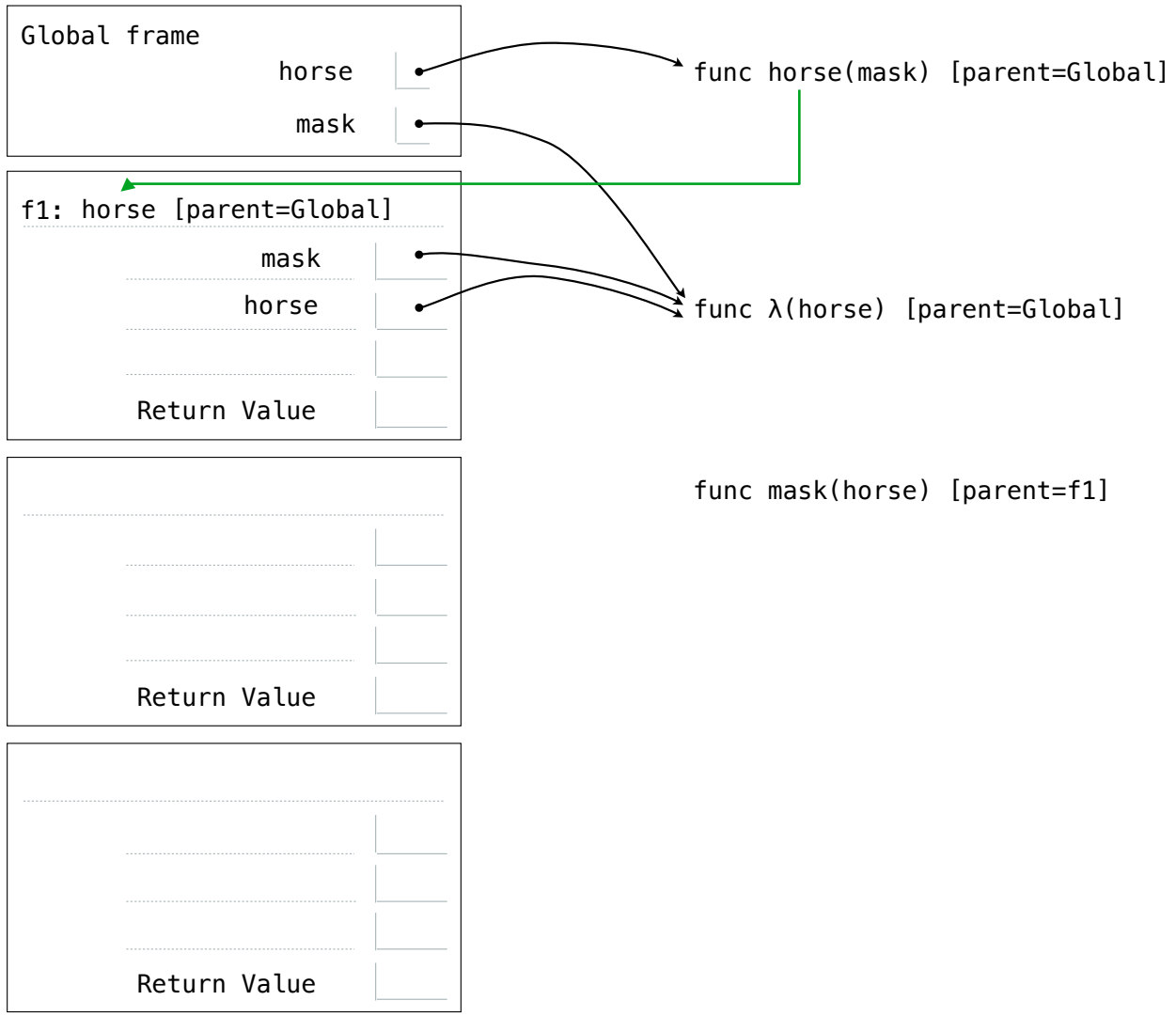

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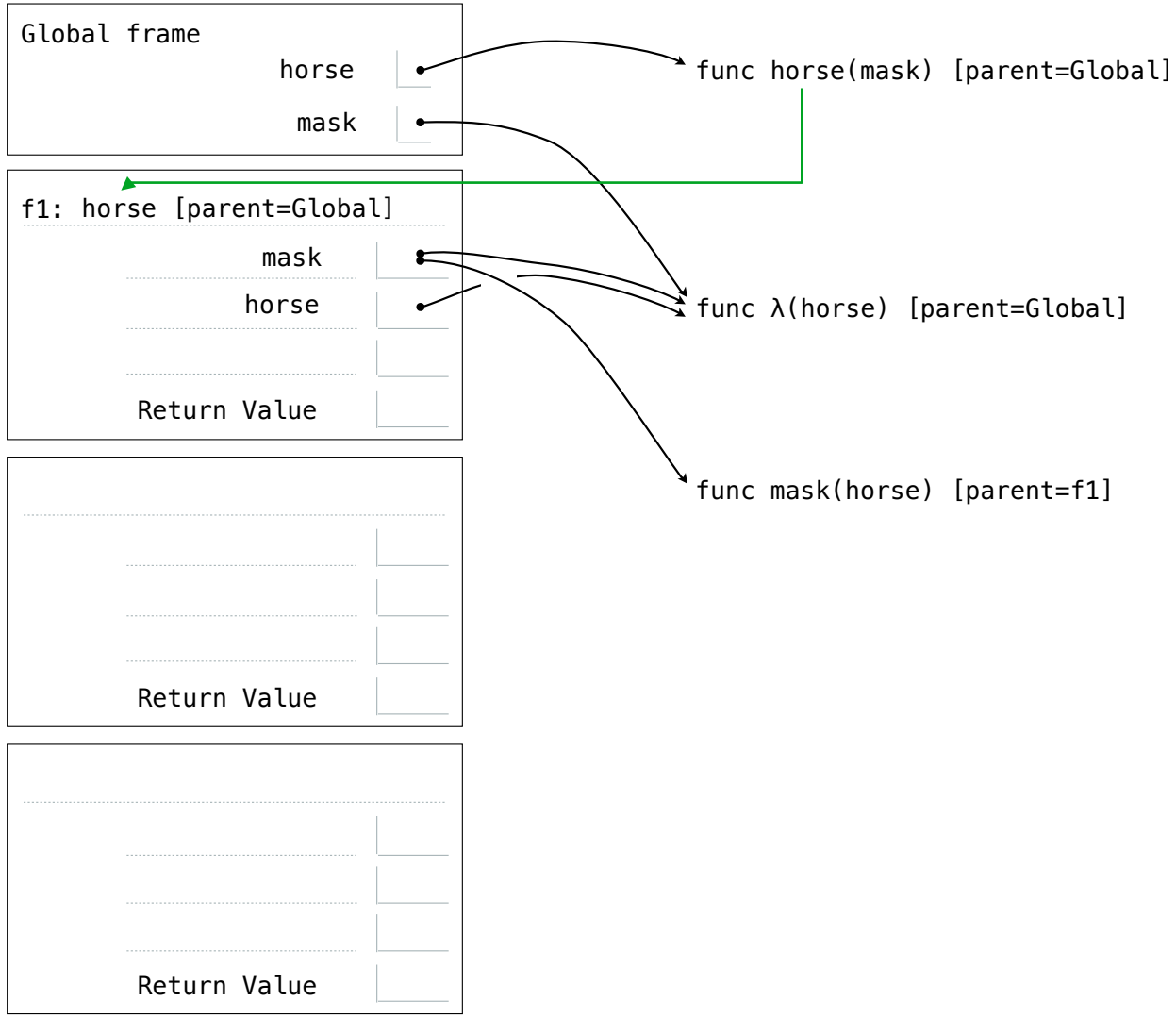

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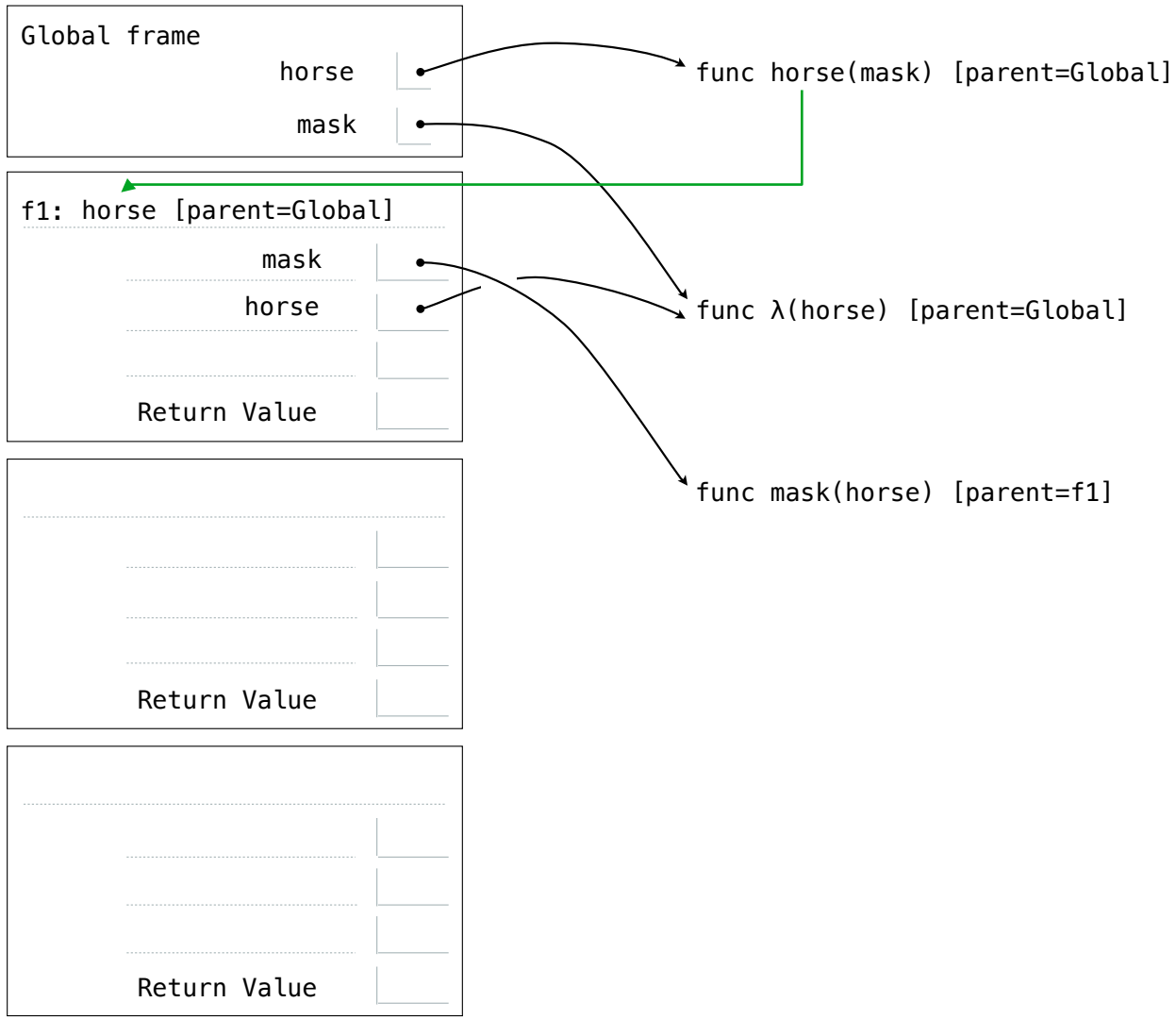

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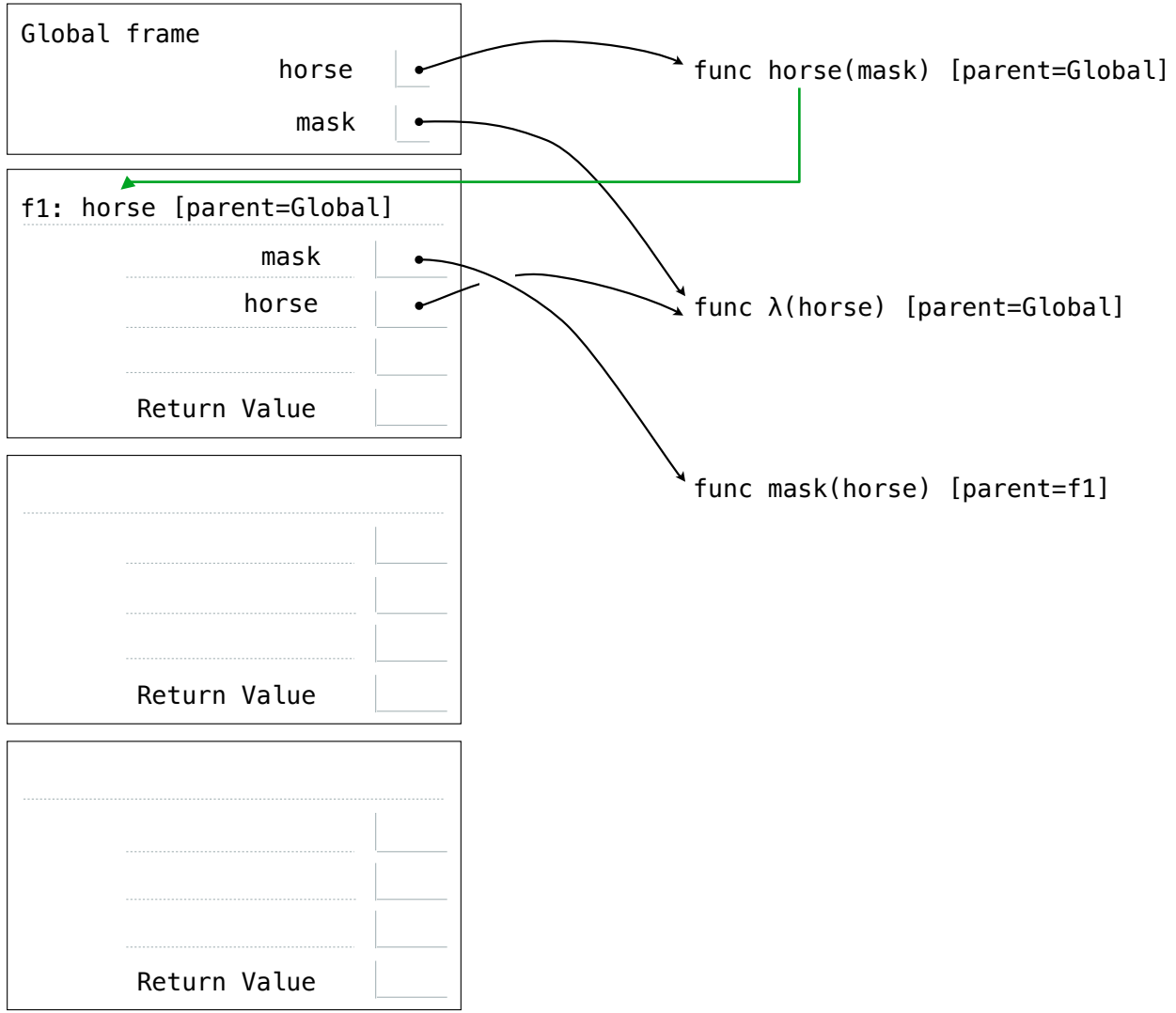

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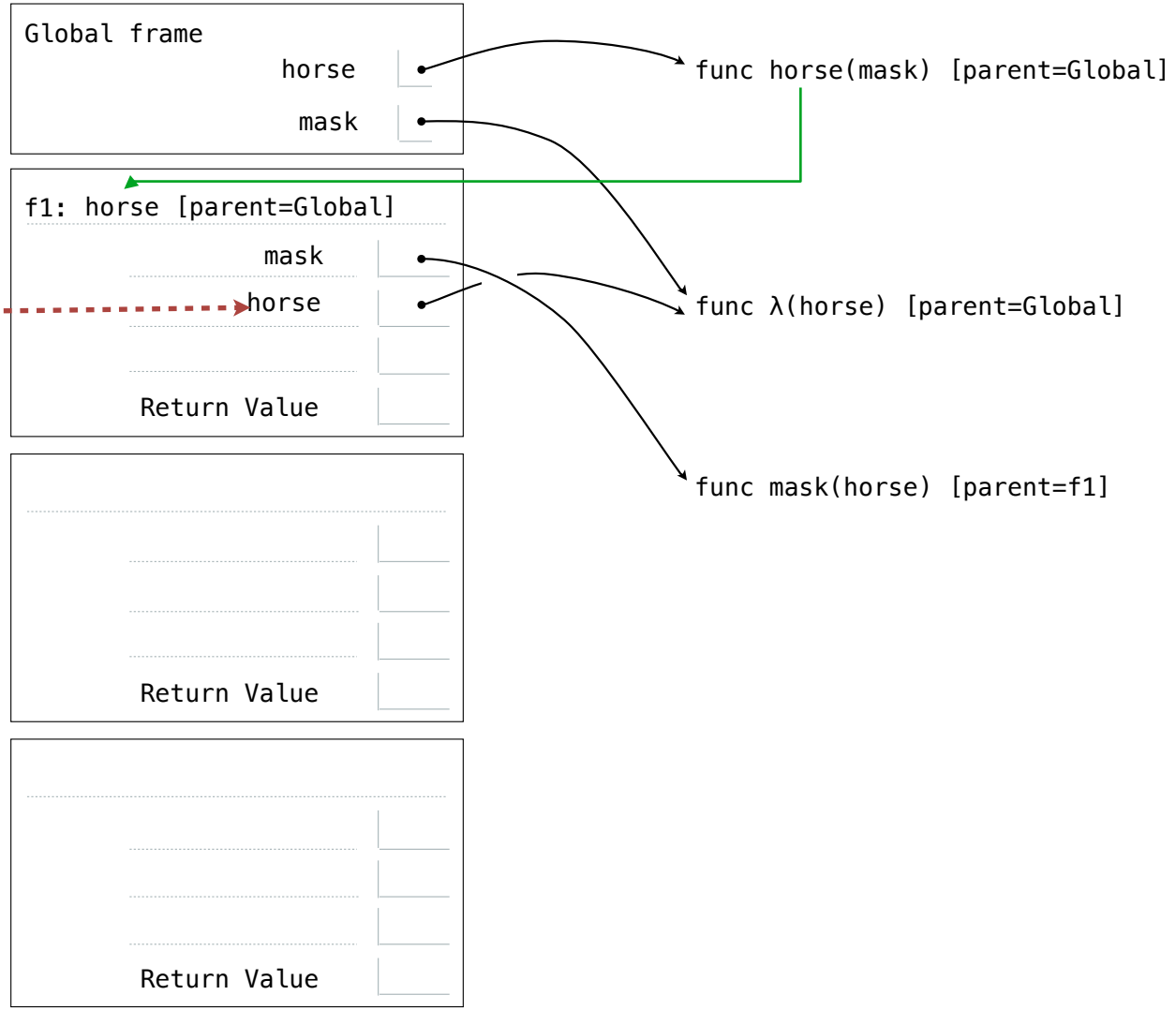

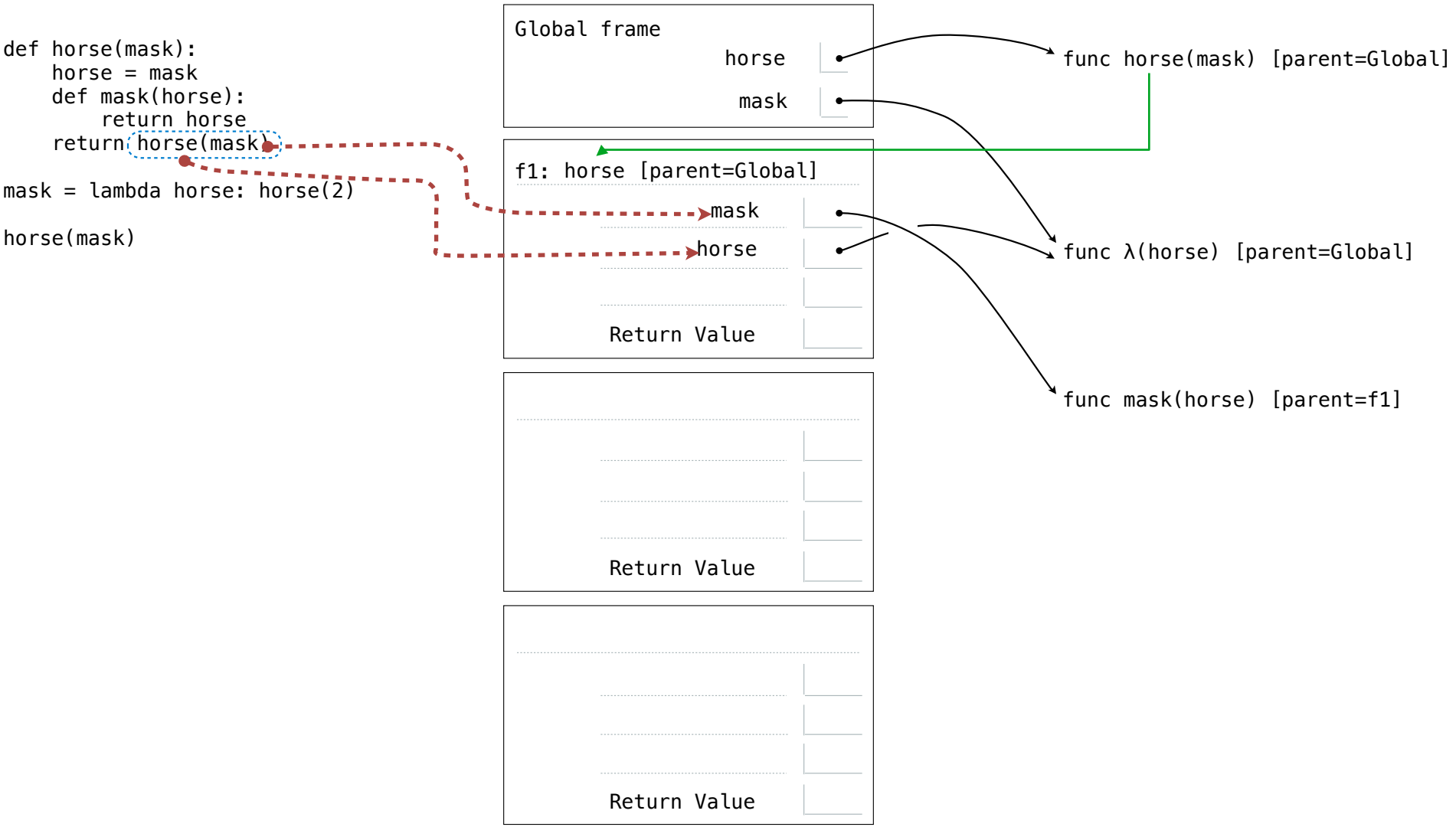
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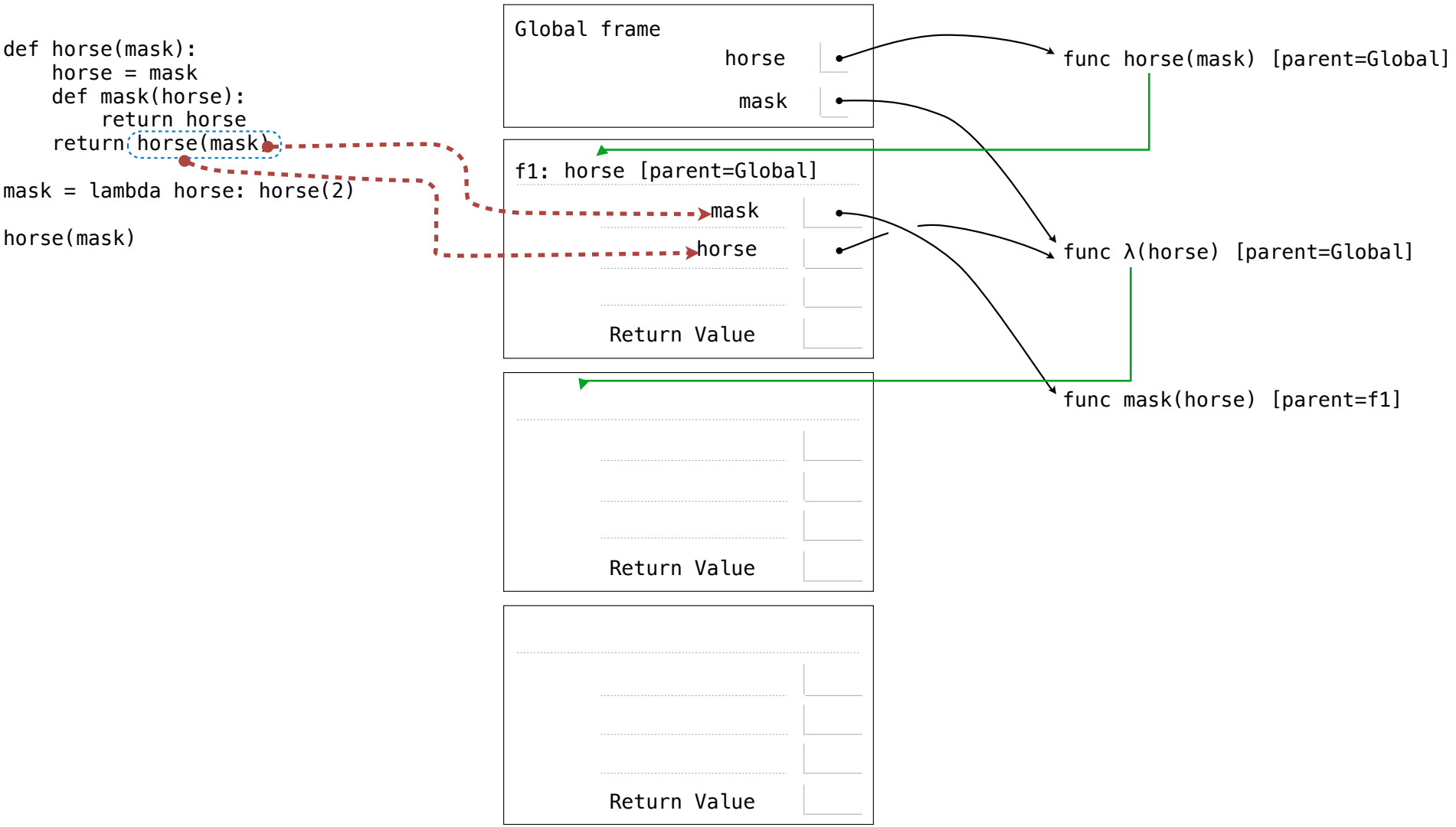
mask = lambda horse: horse(2)
horse(mask)
Global frame
horse
mask
func horse(mask) [parent=Global]
f1: horse [parent=Global]
mask
horse
Return Value
func λ(horse) [parent=Global]
func mask(horse) [parent=f1]
Return Value
Return Value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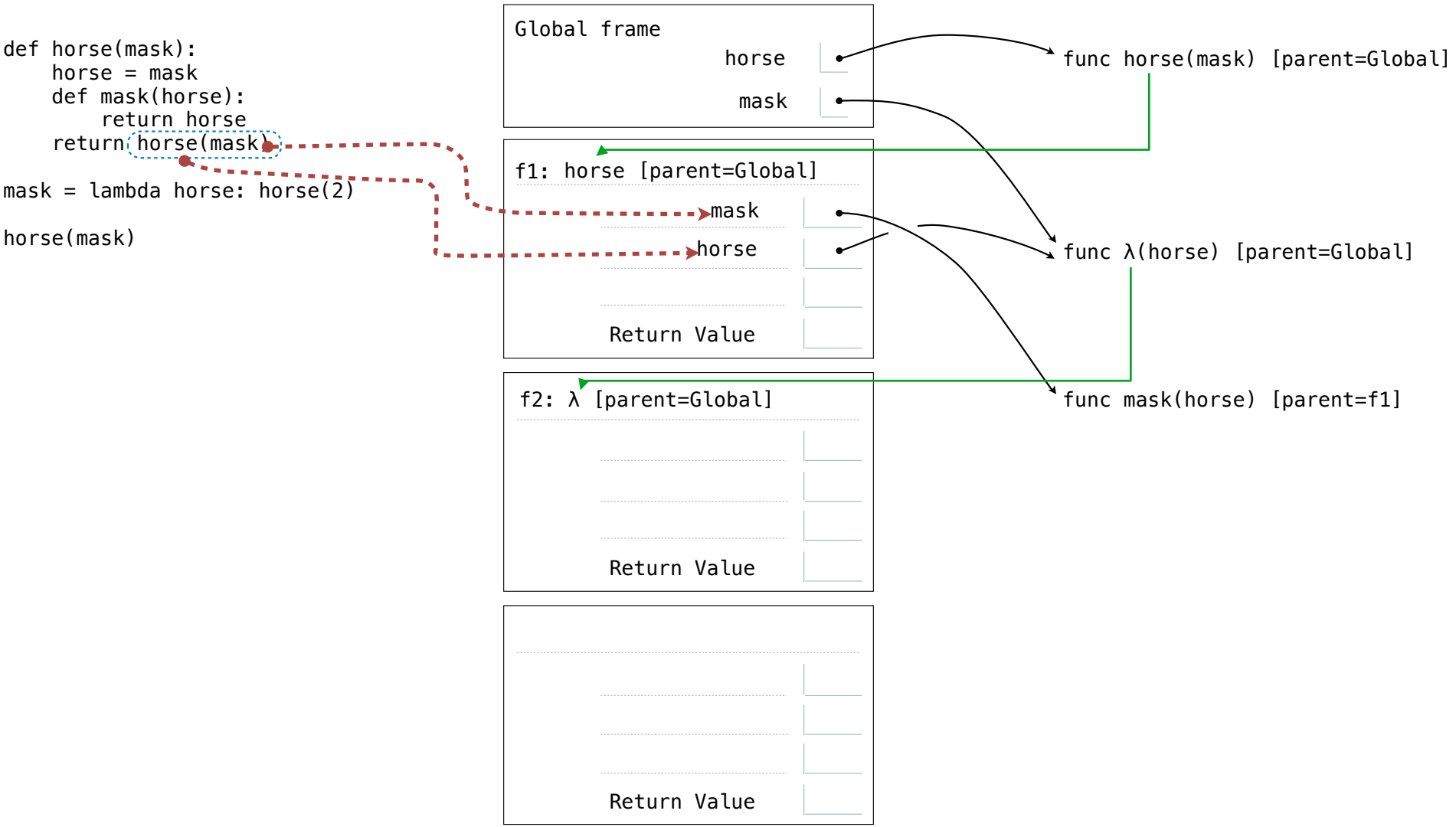
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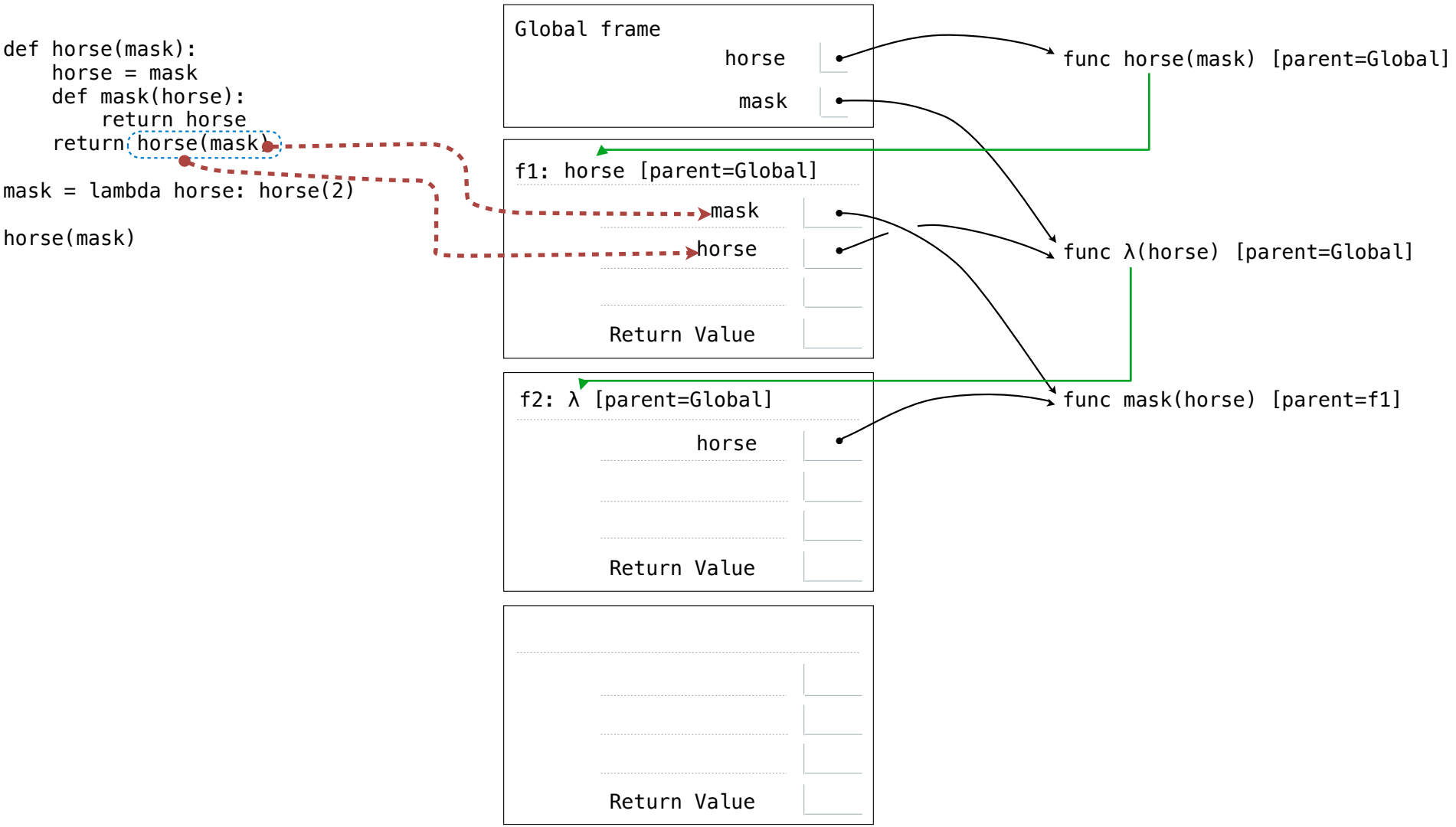
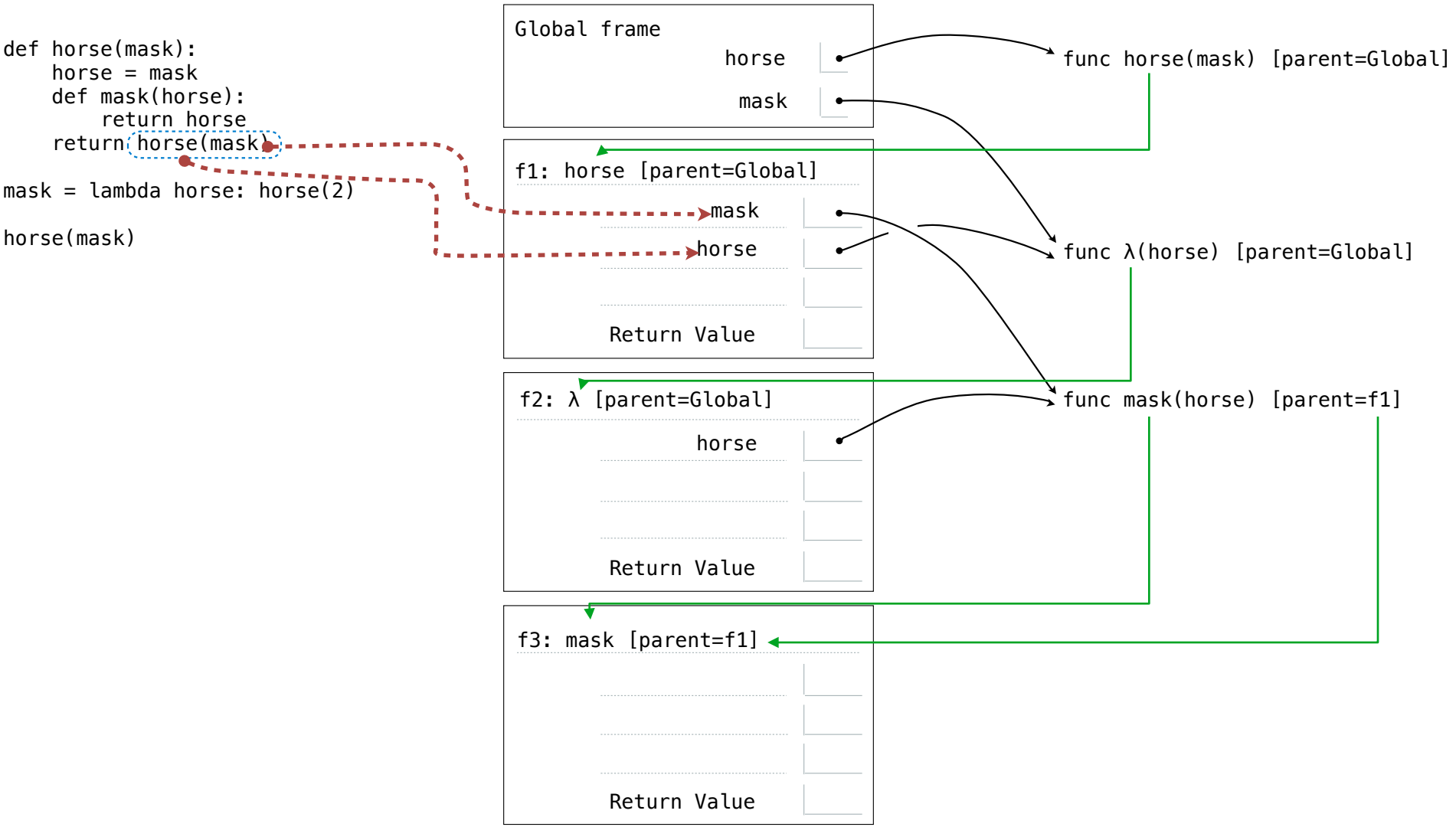
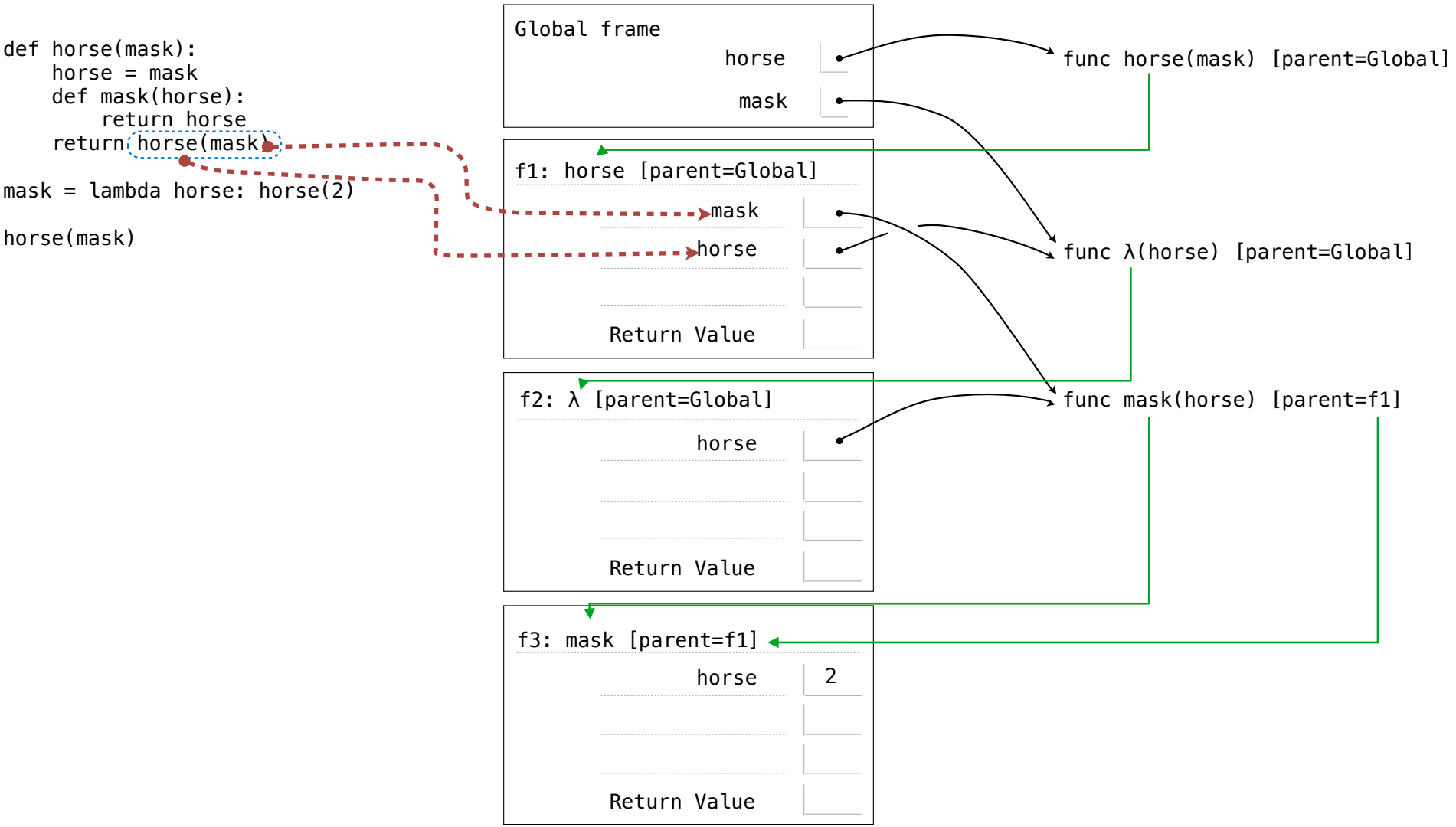
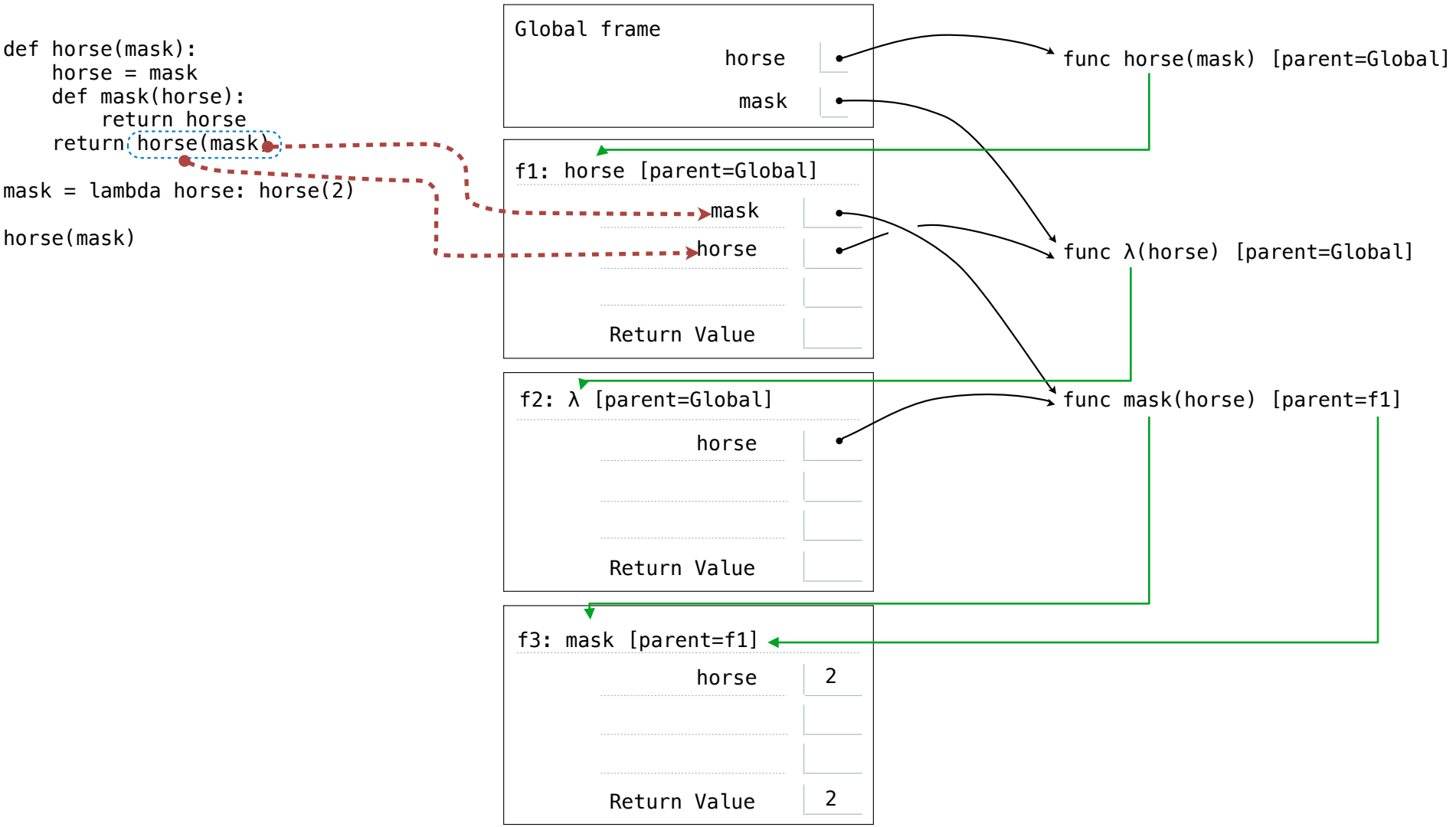
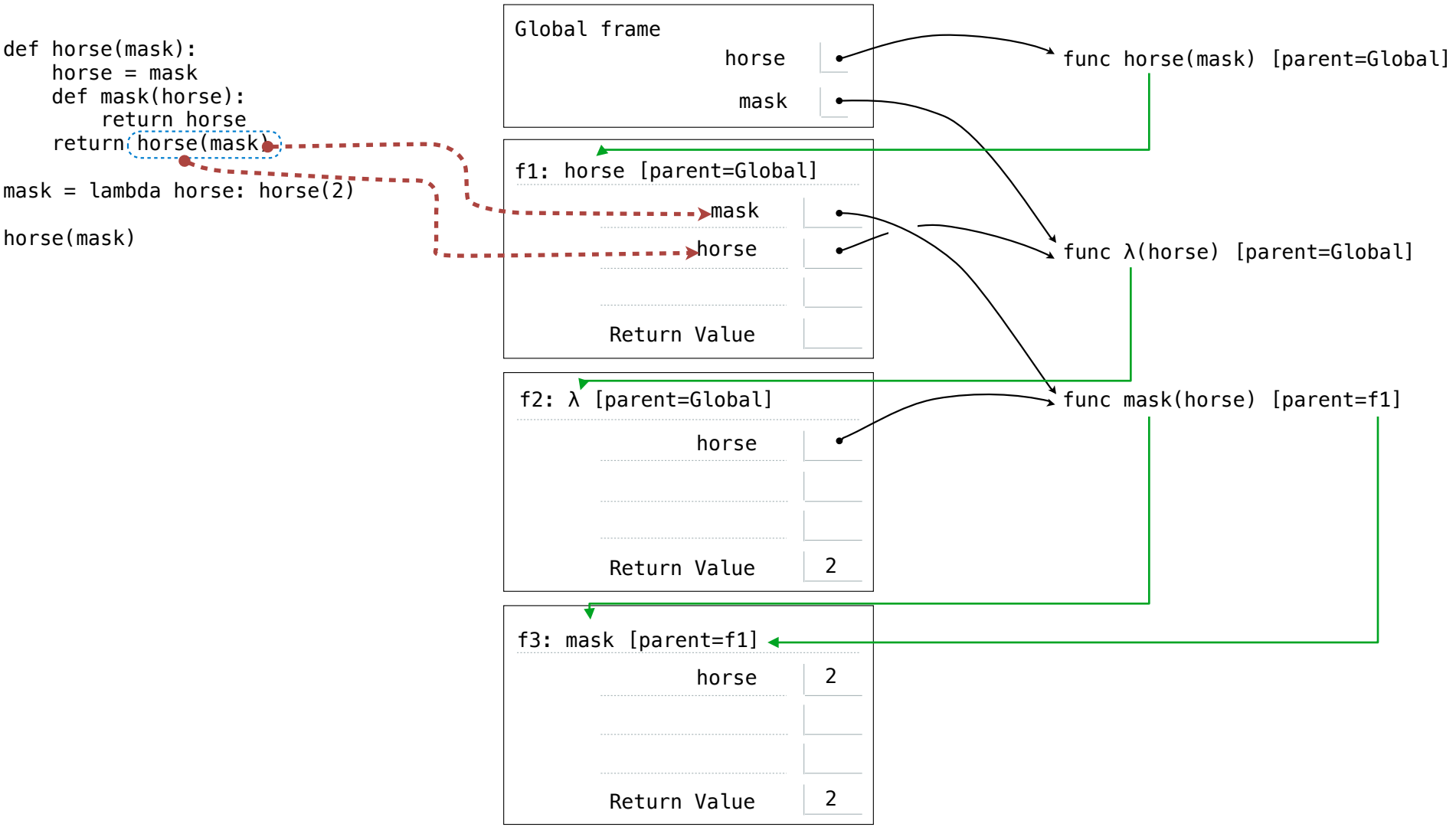
mask
horse
Return Value
func λ(horse) [parent=Global]
f2: λ [parent=Global]
Return Value
func mask(horse) [parent=f1]
Return Value

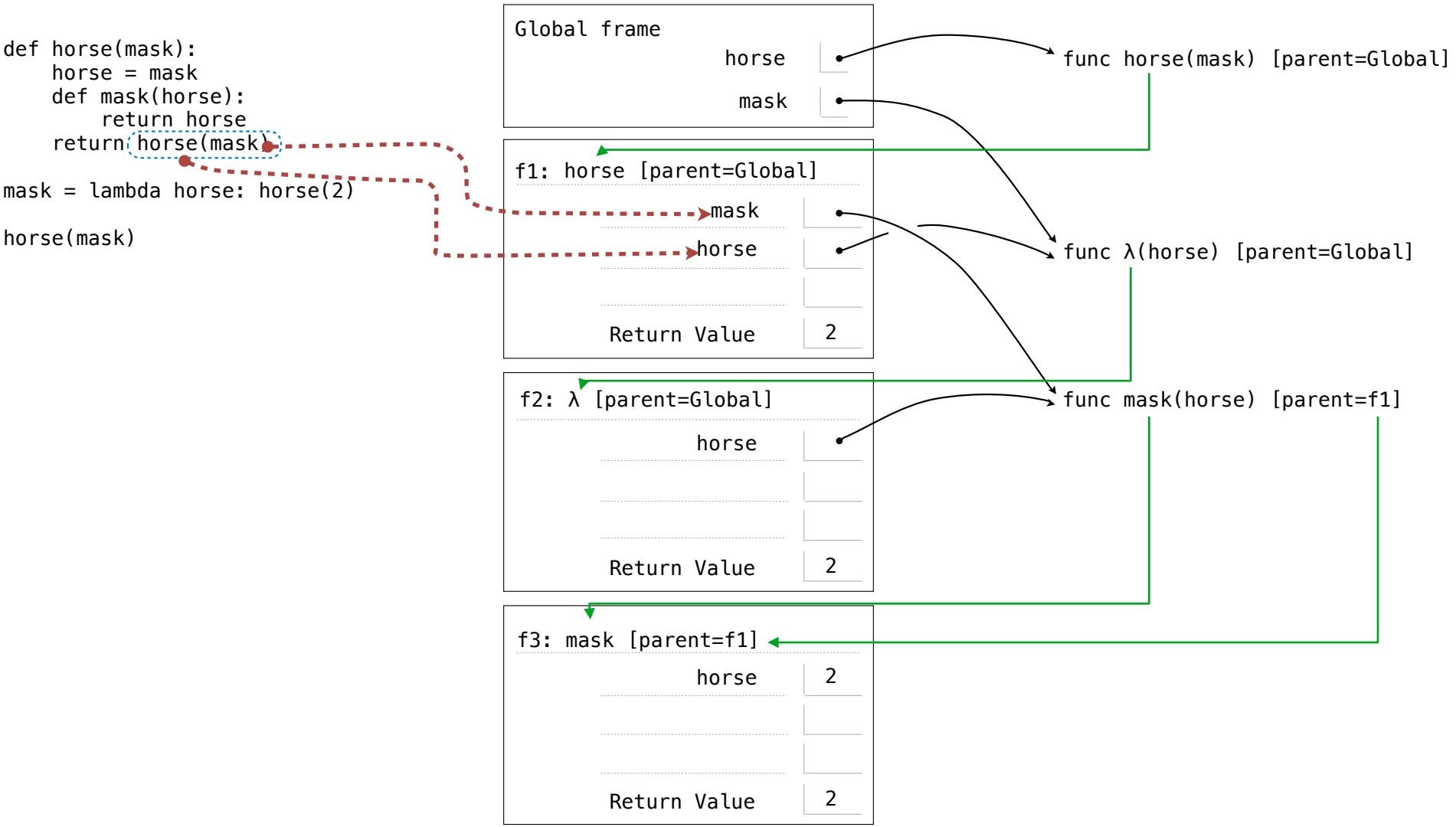

def horse(mask):
horse = mask
def mask(horse):
return horse
return horse(mask)
mask = lambda horse: horse(2)
horse(mask)
Global frame
horse
mask
func horse(mask) [parent=Global]
f1: horse [parent=Global]
mask
horse
Return Value
func λ(horse) [parent=Global]
f2: λ [parent=Global]
horse
Return Value
func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


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


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


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


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
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


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