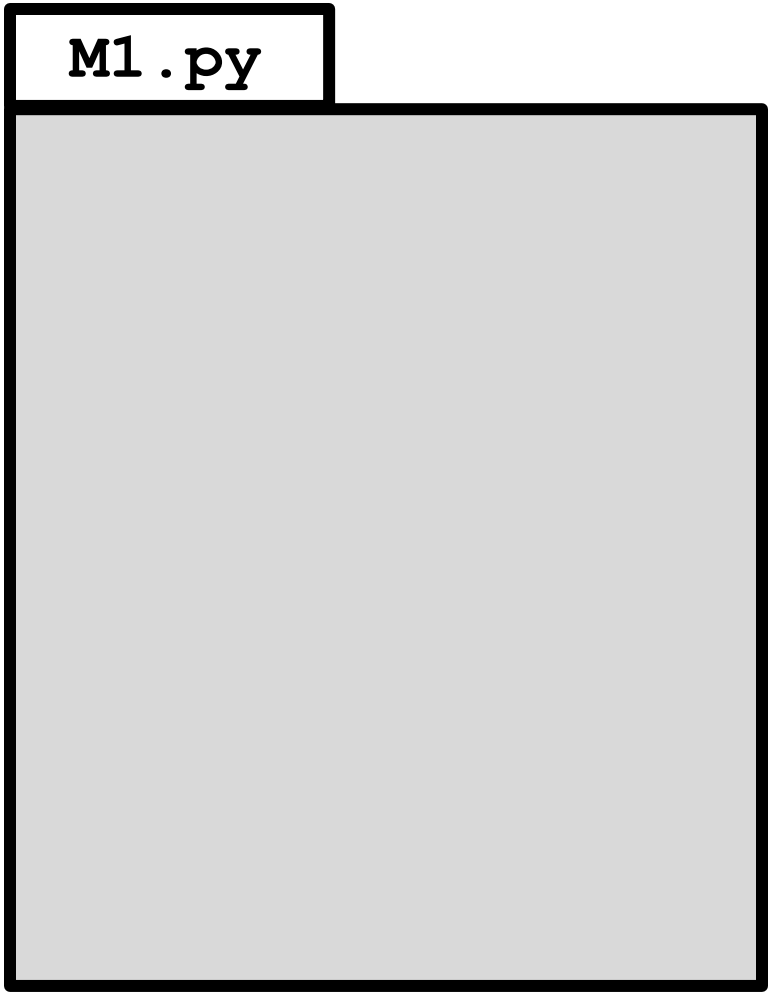
6. How Modules and Functions Work

Topics:

- Modules and Functions
- More on Importing
- Call Frames

Let's Talk About Modules

What Are They?

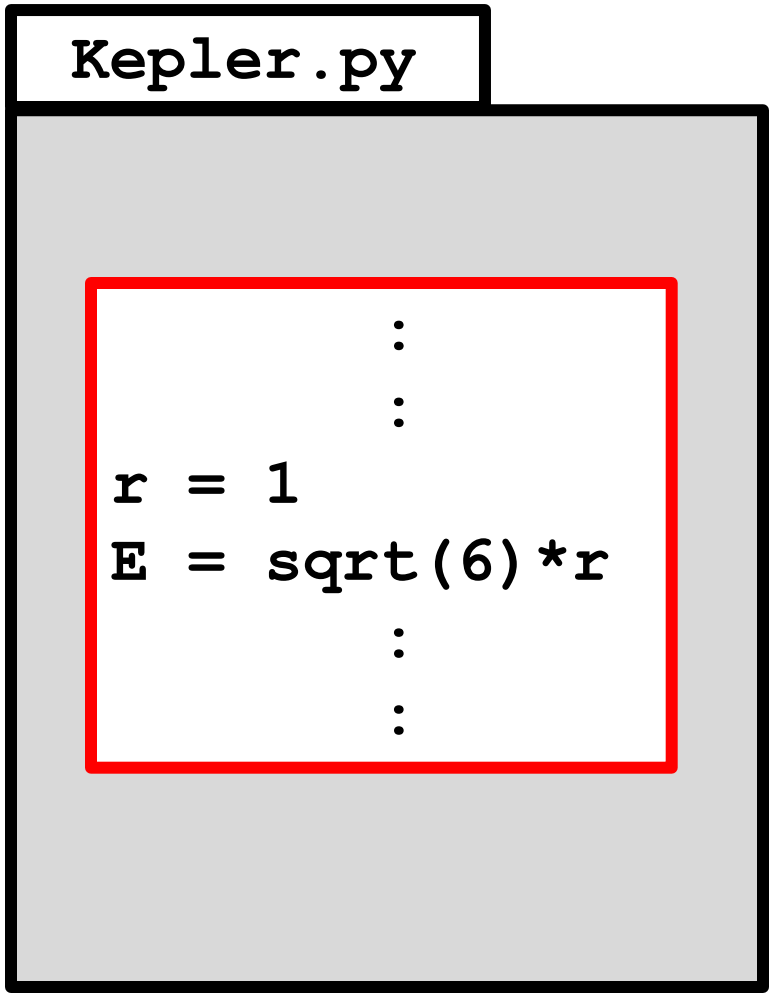


A module is a .py file that contains Python code

The name of the module is the name of the file. This is the module **`M1.py`**

We draw a module as a folder with a black outline.

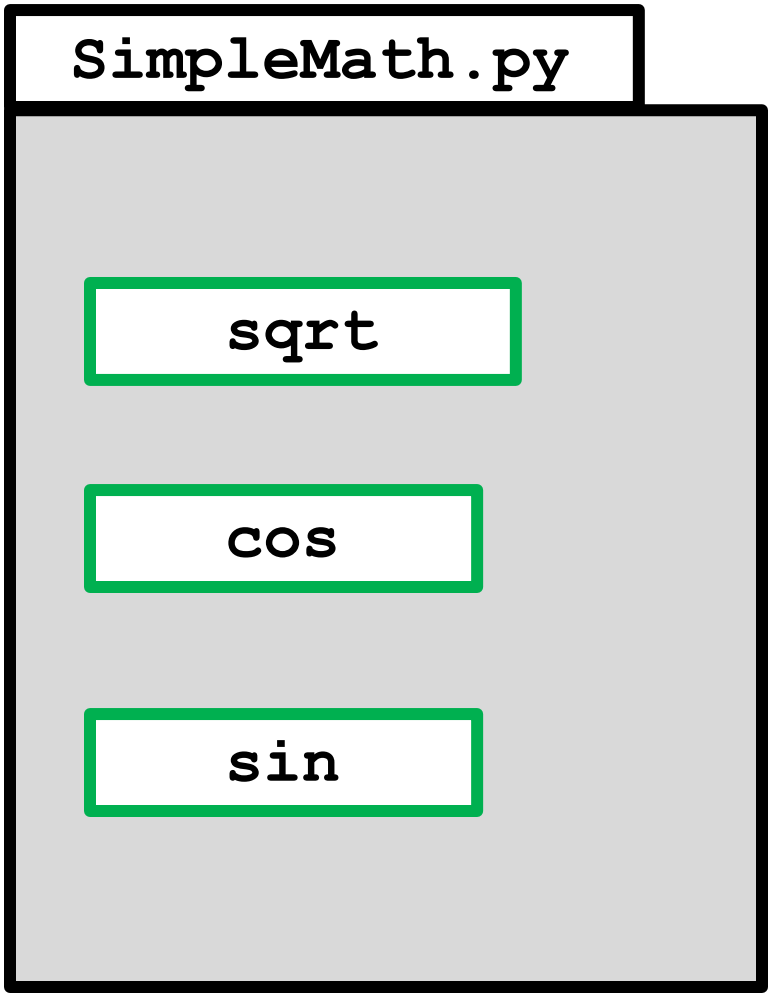
Inside a Module



A module may contain a single script.

A script will be shown as a rectangle with a red border.

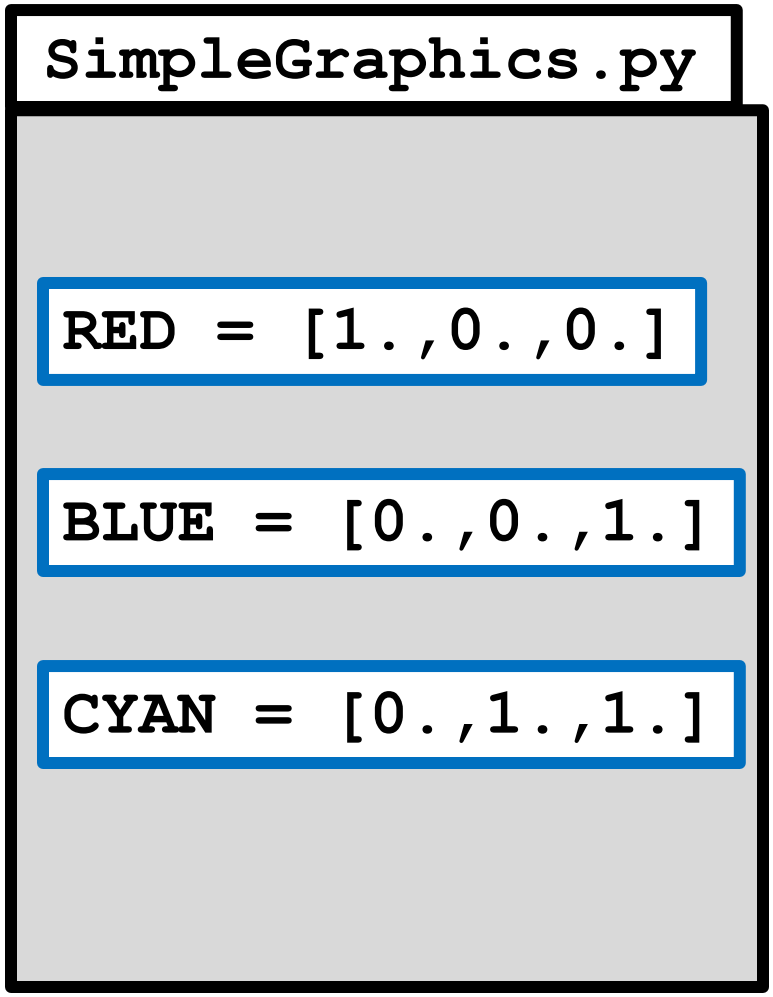
Inside a Module



A module may contain one or more function definitions.

Functions will be shown as rectangles with green borders.

Inside a Module

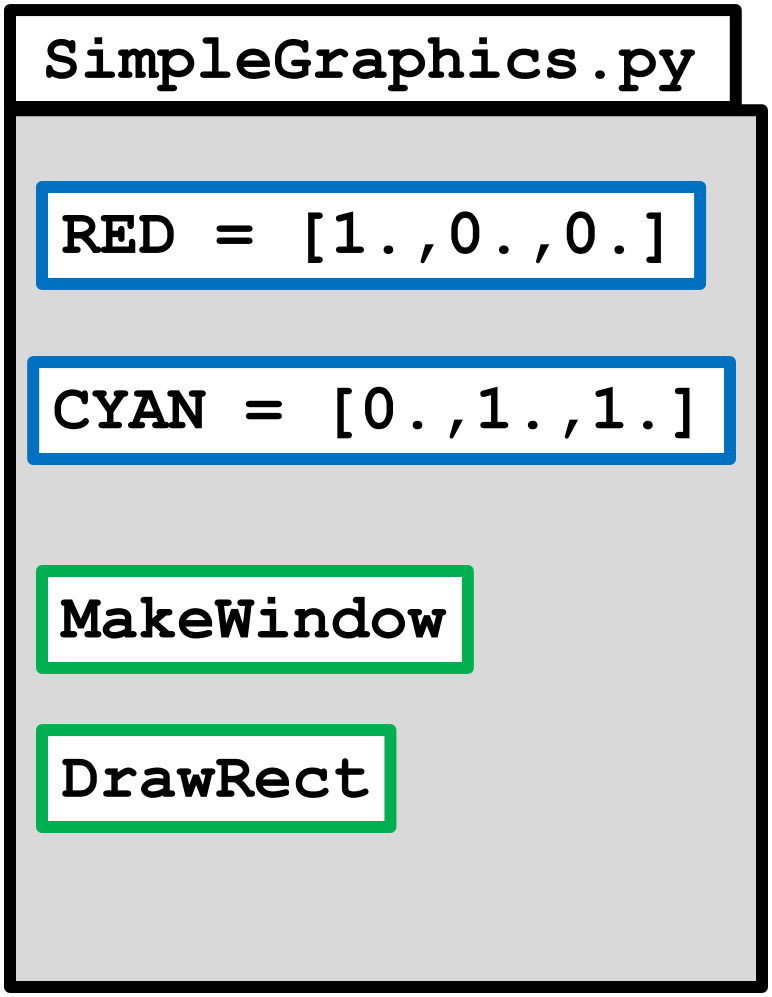


A module may contain one or more data items.

These are referred to as global variables. They should be treated as constants whose values are never changed.

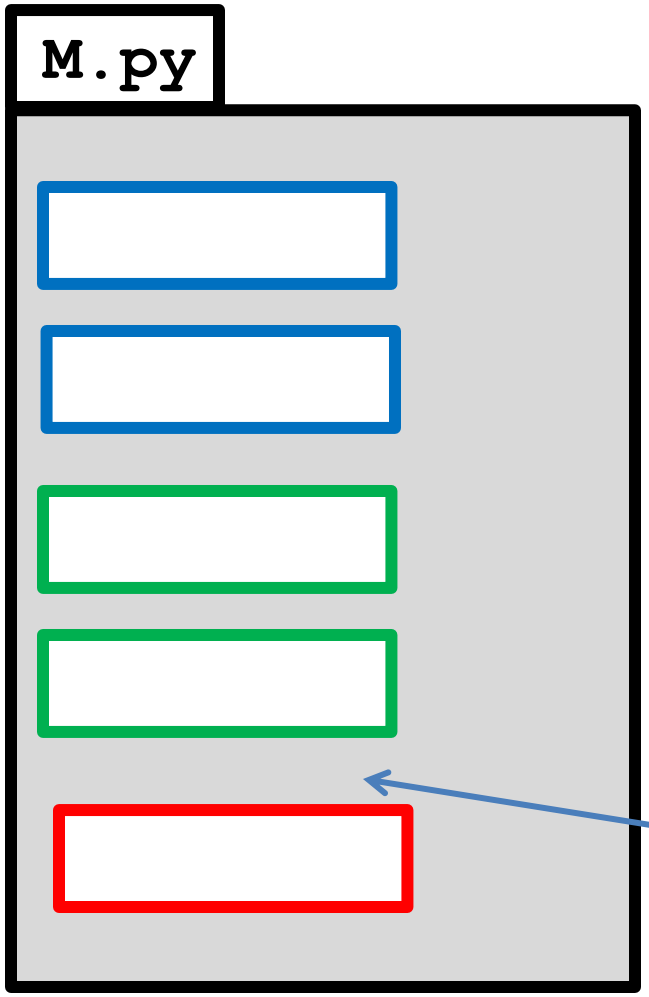
Data items will be shown as rectangles with blue borders.

Inside a Module



A module may contain one or more data items and one or more functions.

Inside a Module



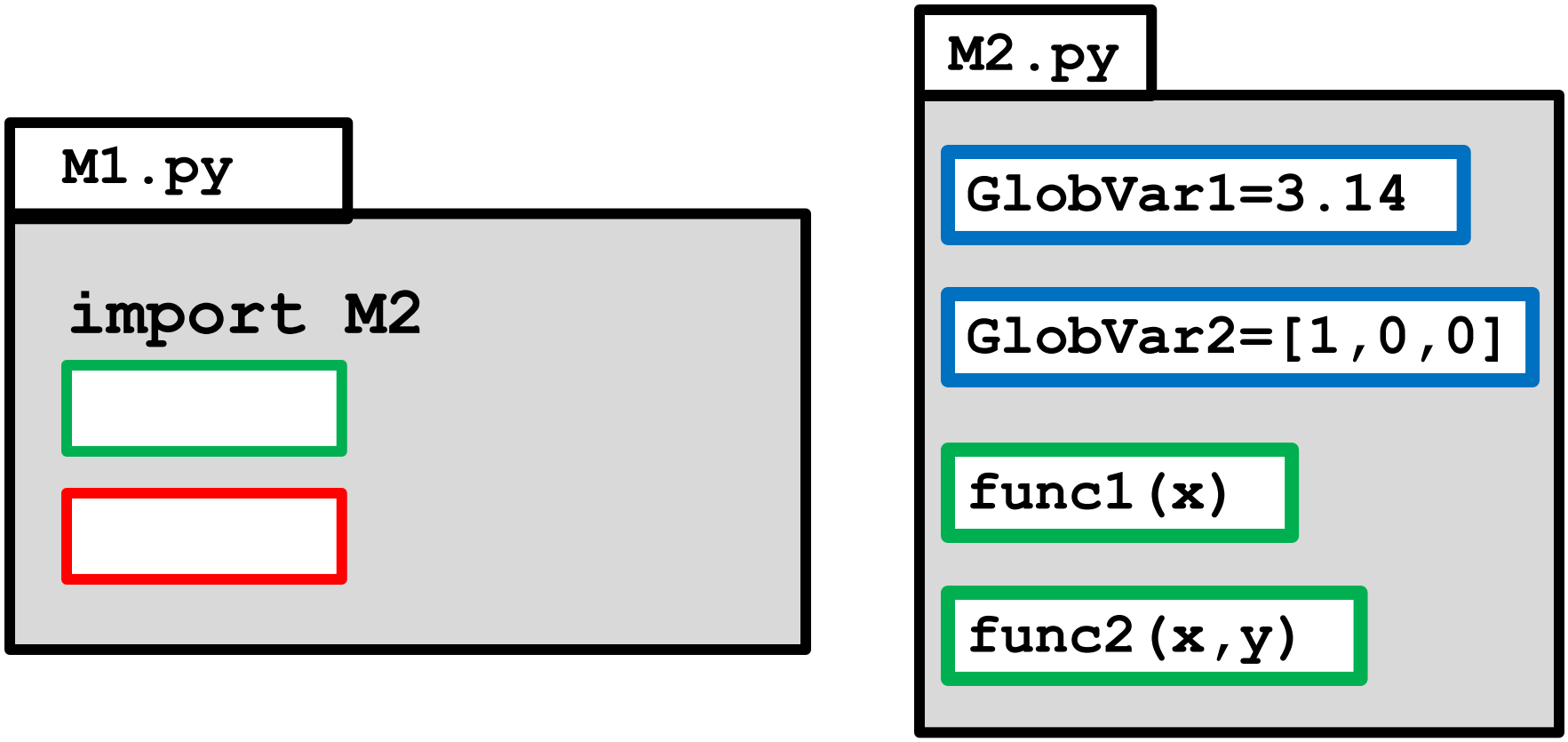
A module may contain one or more data items and one or more functions and a script.

But in this case, the script MUST be prefaced by

```
if __name__ == __main__:
```

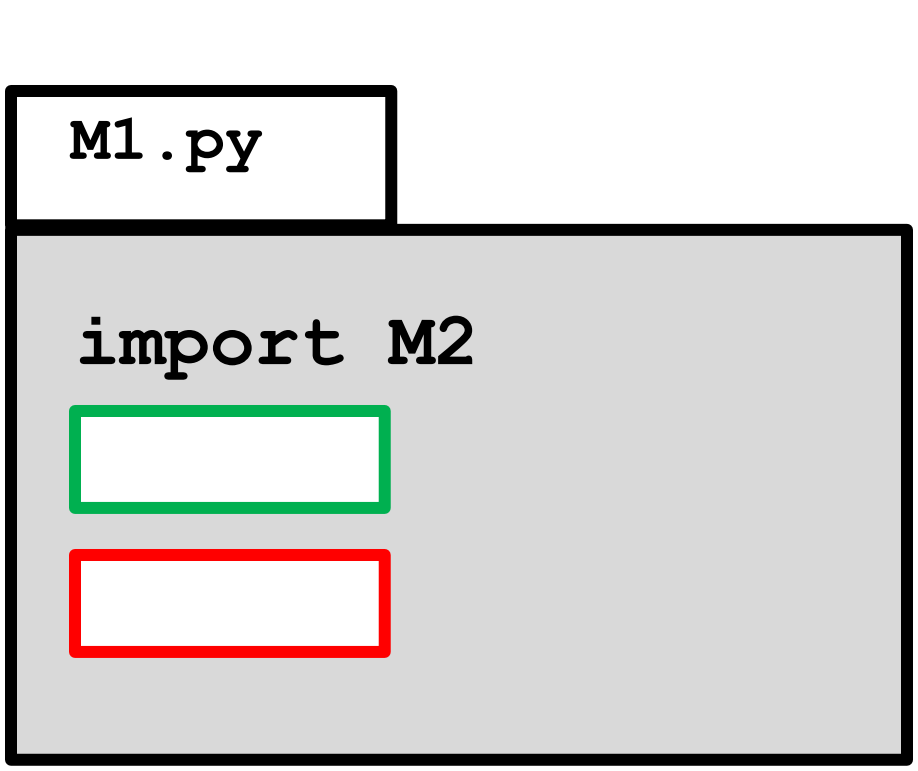
Let's Talk About `import`

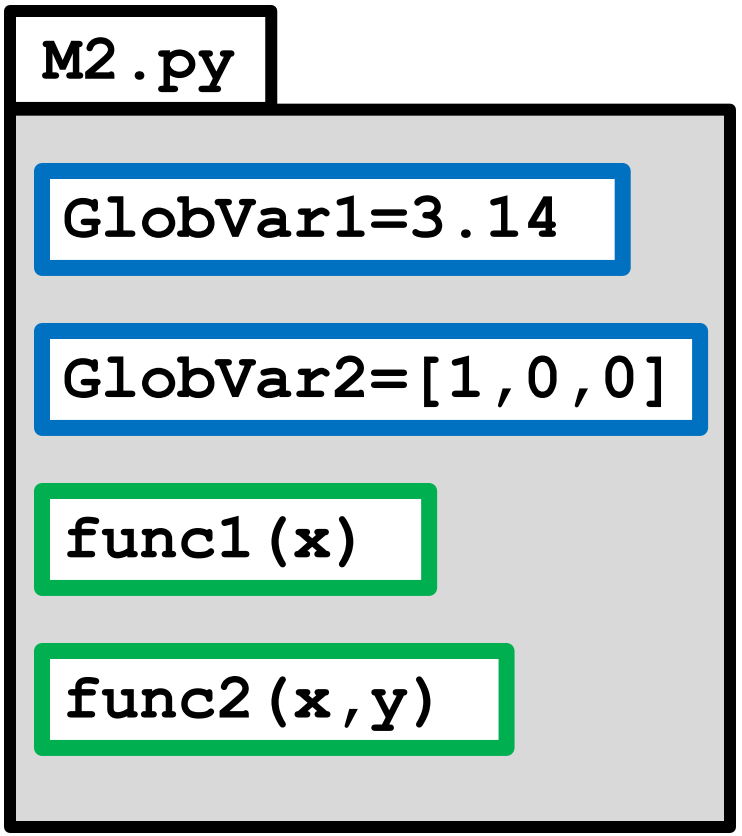
What Does `import` Allow?



It means that code inside `M1.py` can reference the data and functions inside `M2.py`

What Does import Allow?

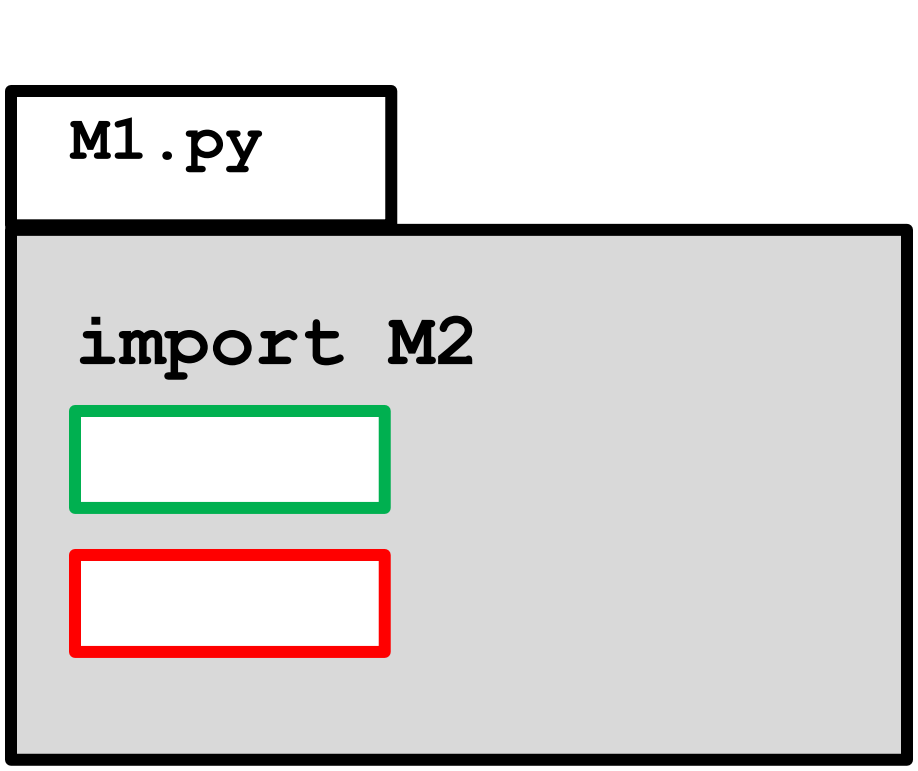


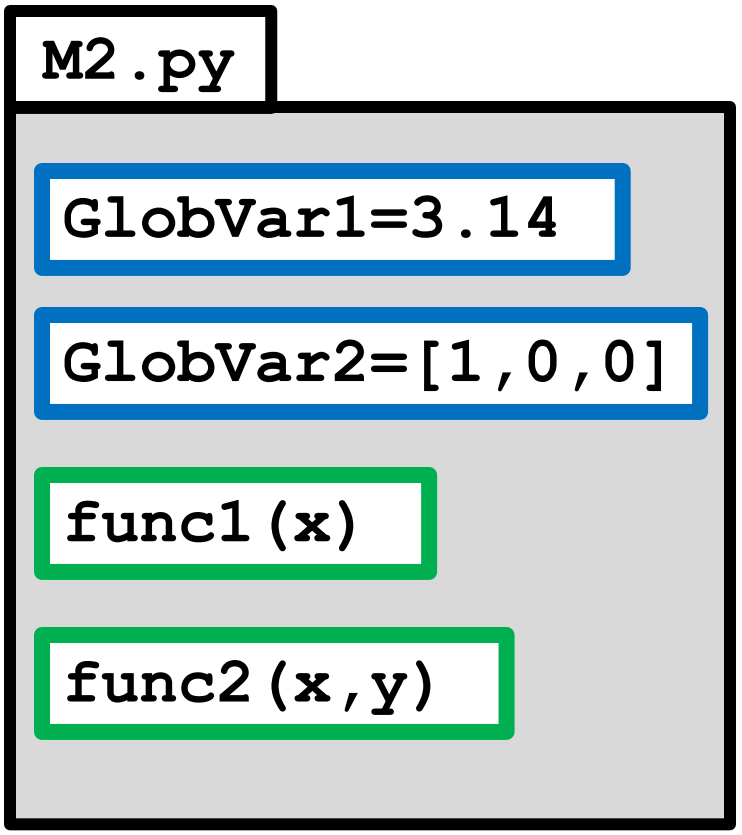


A function ☐ in M1.py could have a line like

```
a = M2.func2(x,M2.GlobVar1)
```

What Does `import` Allow?

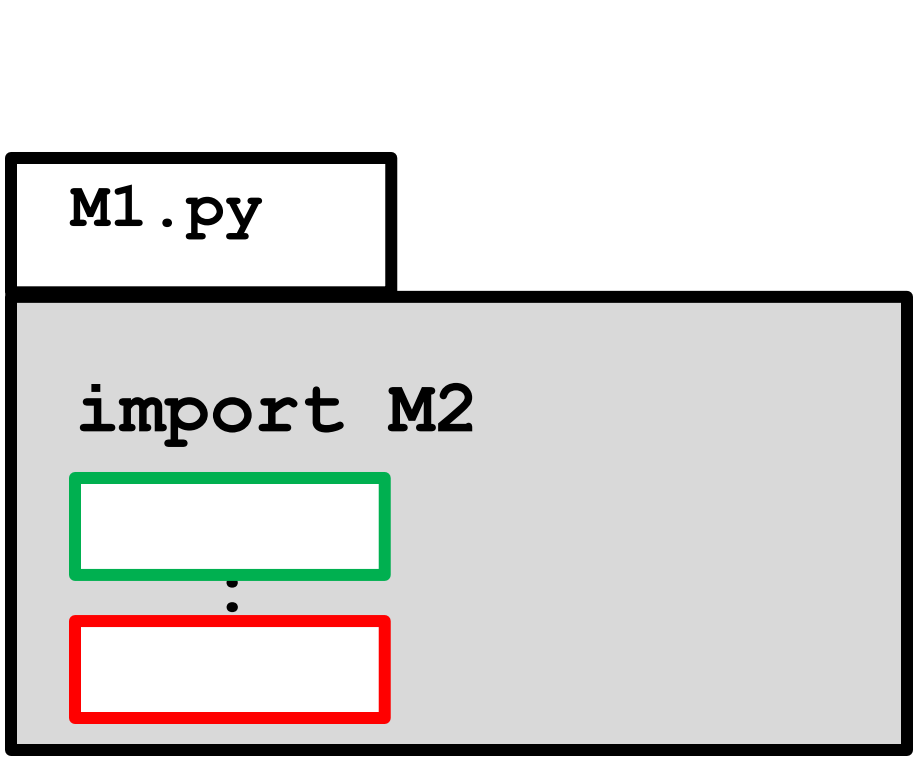


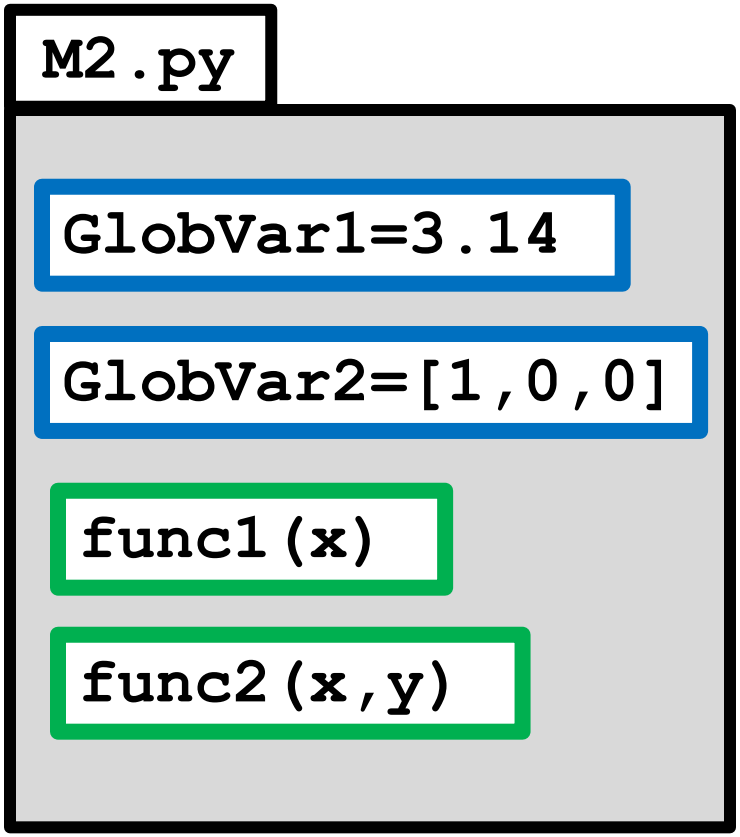


The script  in `M1.py` could have a line like

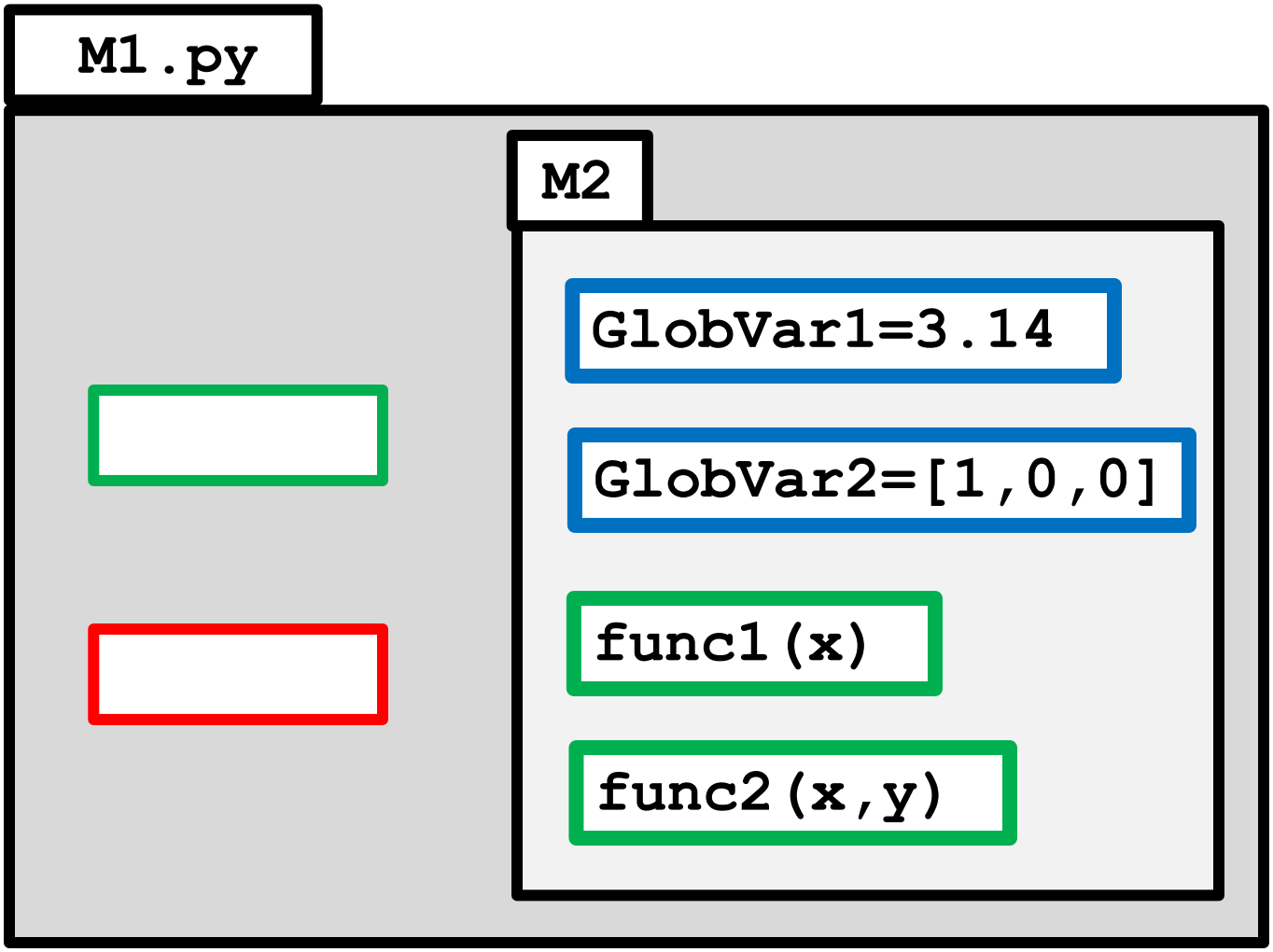
```
a = M2.func1(M2.GlobVar1)
```

One Way to Think About this…



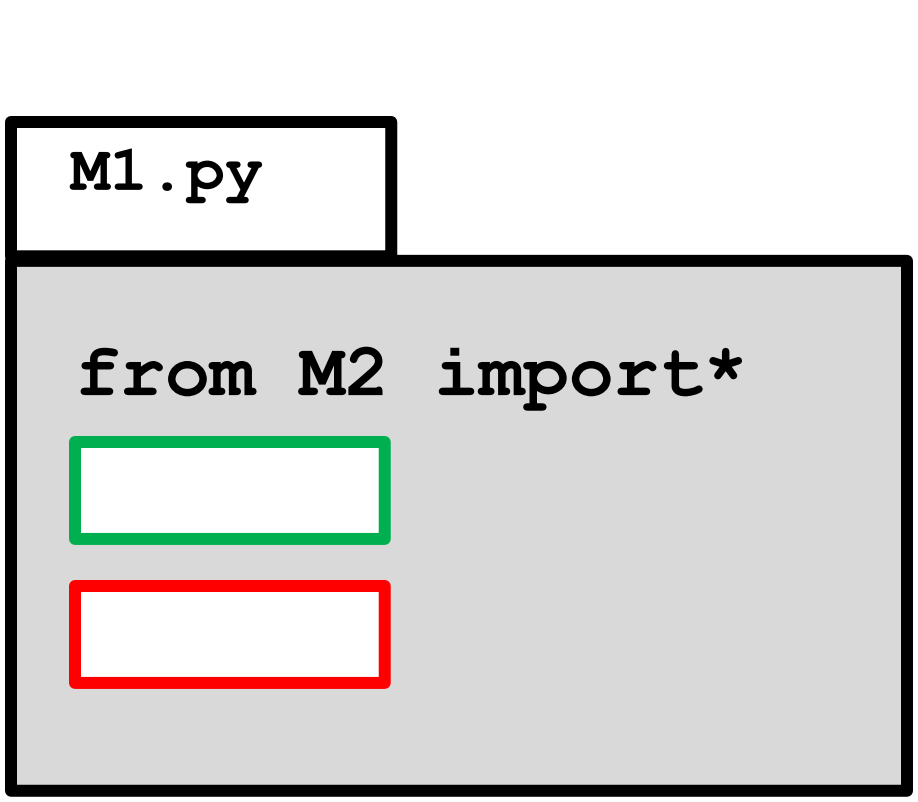


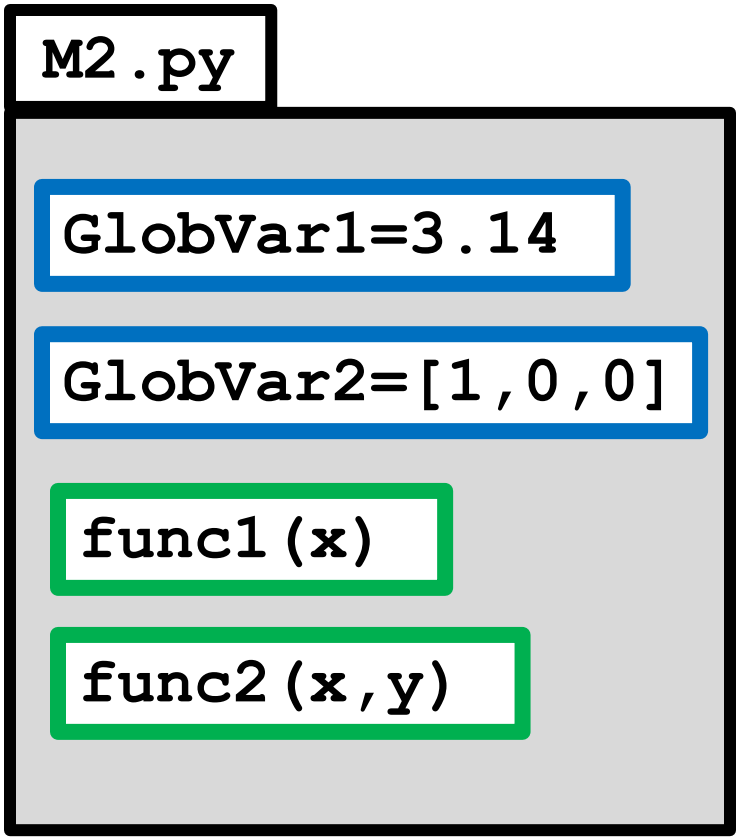
is like this…



Module `M1.py` contains a folder called `M2`. Need the "dot notation" to extract what is in `M2`.

What Does import* Allow?

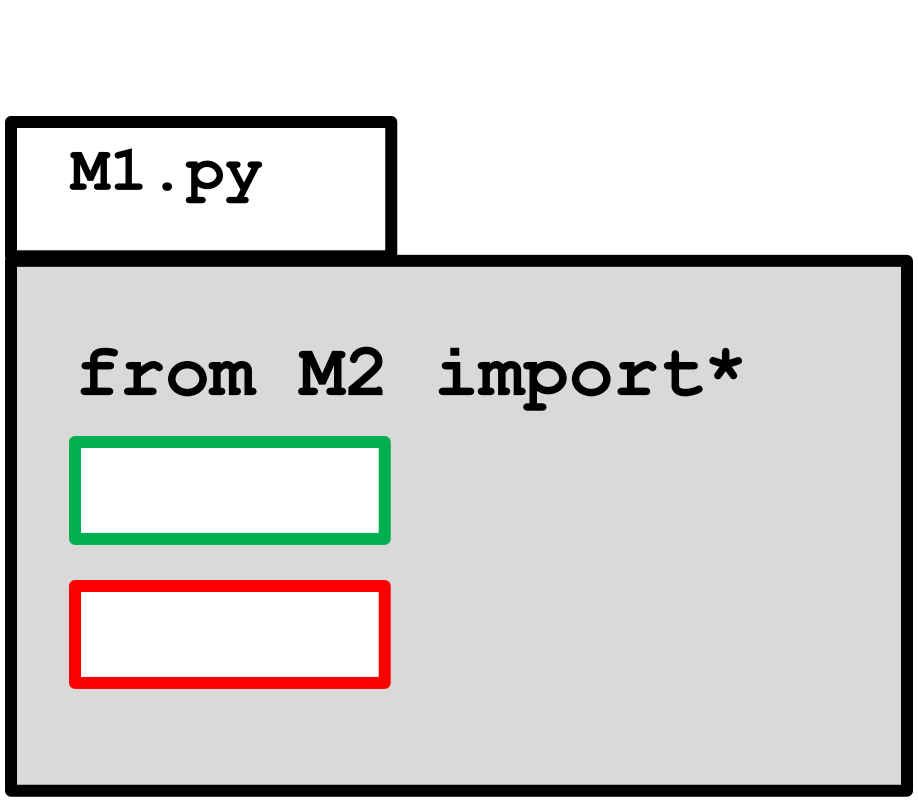


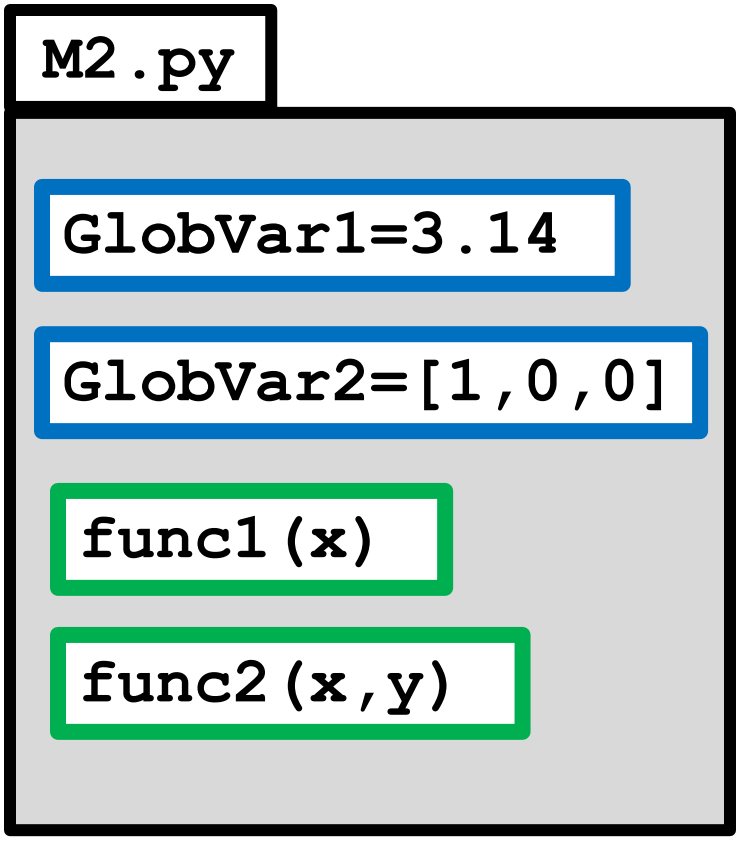


A function ☐ in M1.py could have a line like `a = func1(x,GlobalVar2)`

No dot notation

What Does import* Allow?

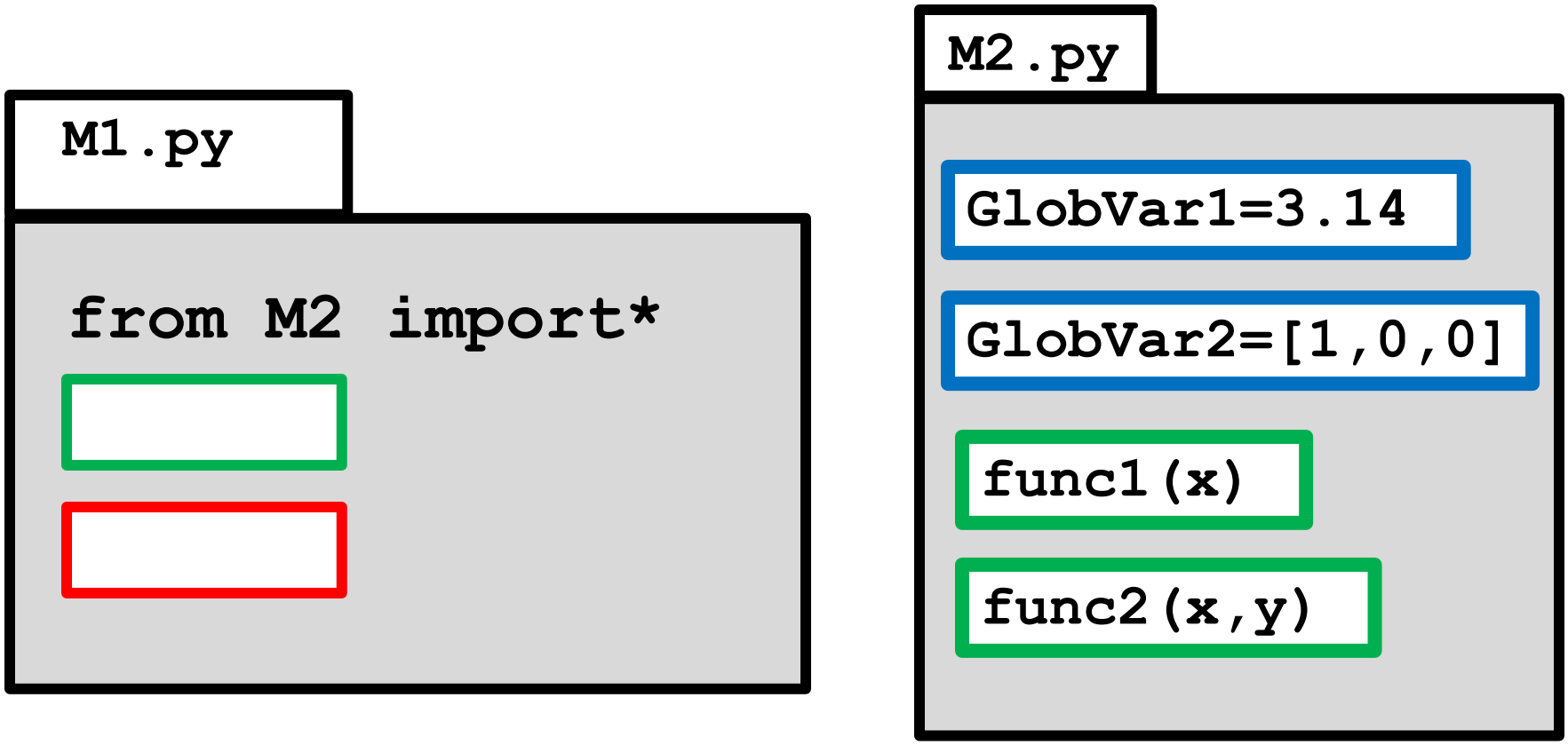




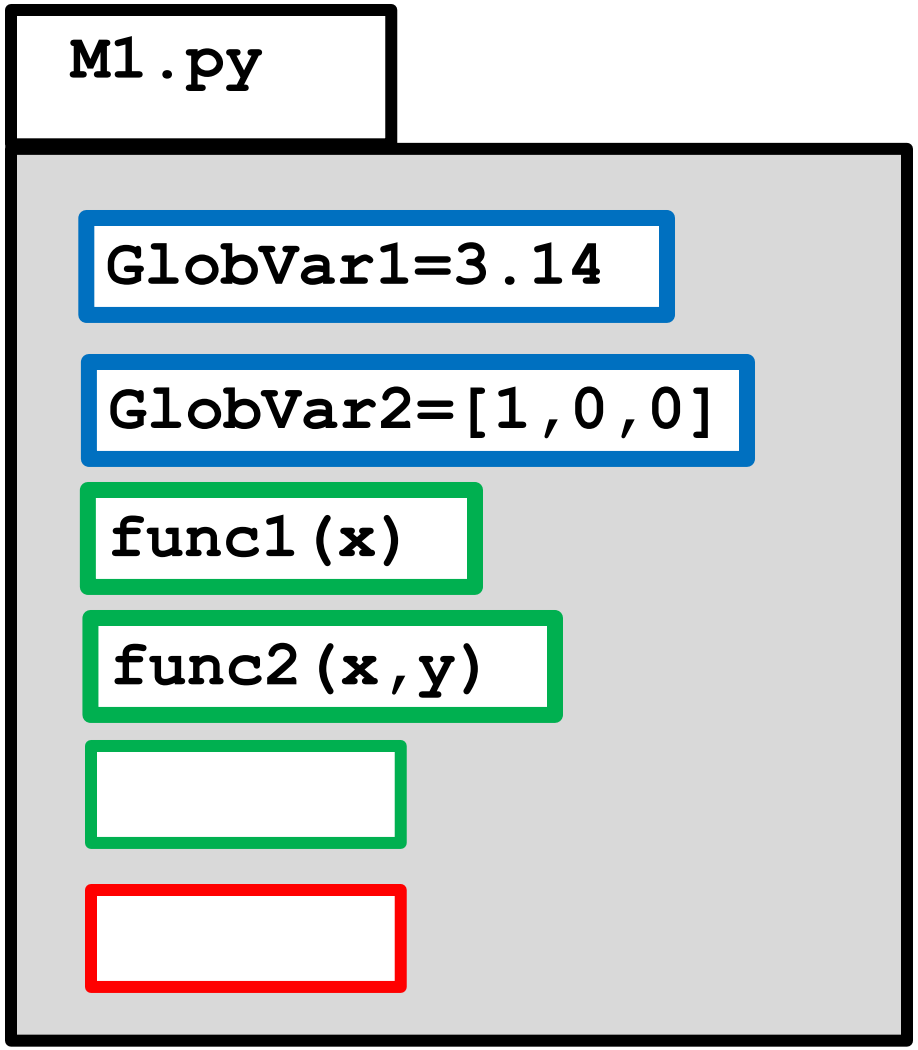
A script ▭ in `M1.py` could have a line like `a = func2(x,GlobalVar2)`

No dot notation

One way to Think about this…

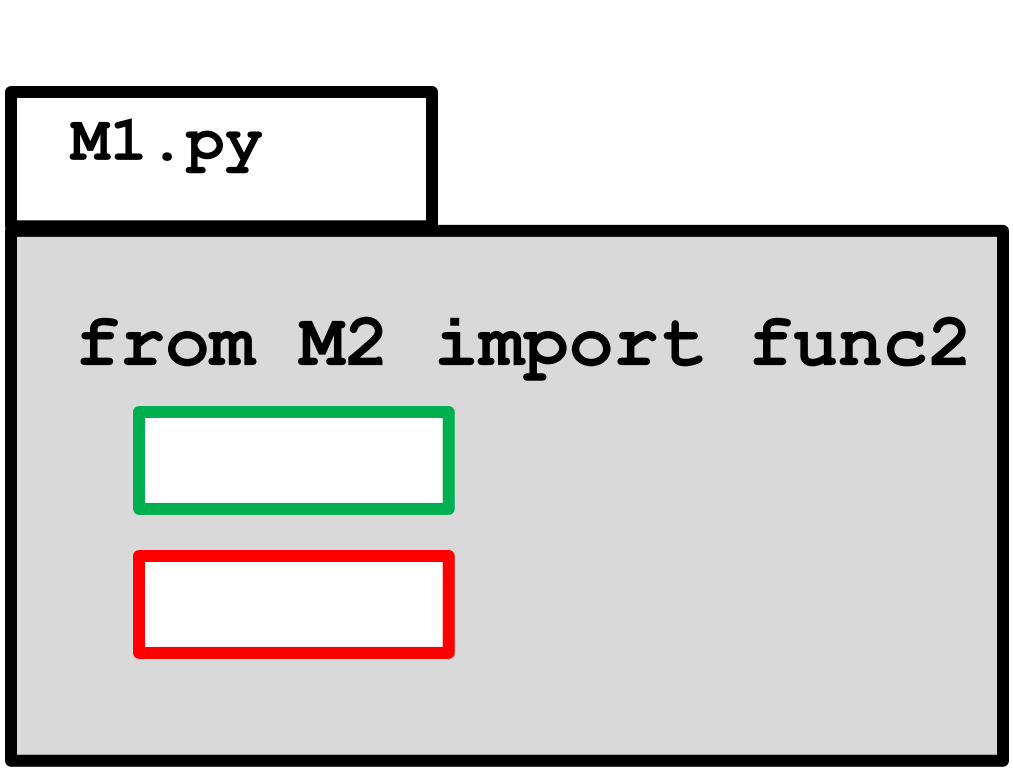


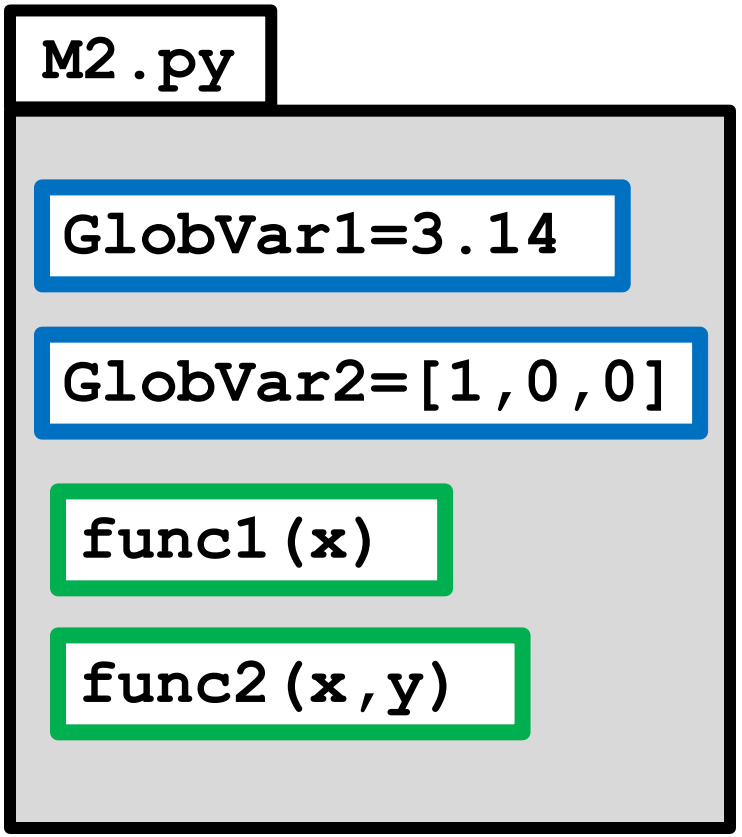
is like this…



It is as if `GlobVar1`, `GlobVar2`, `func1`, and `func2` were defined in `M1.py`

"Specific" Importing

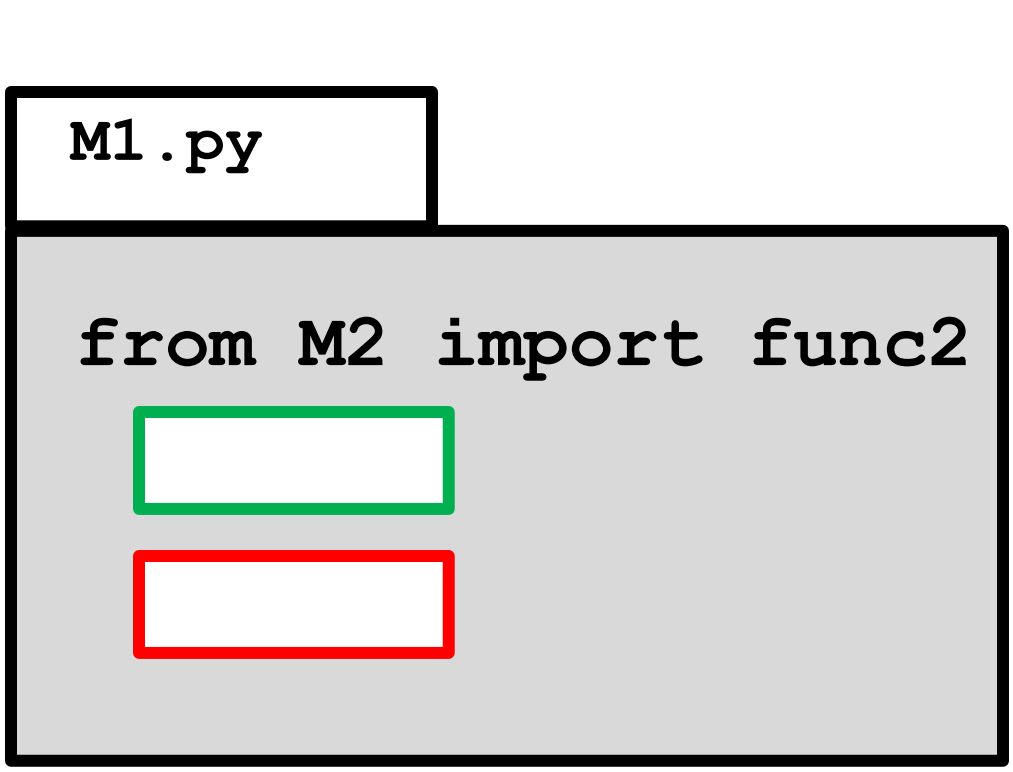


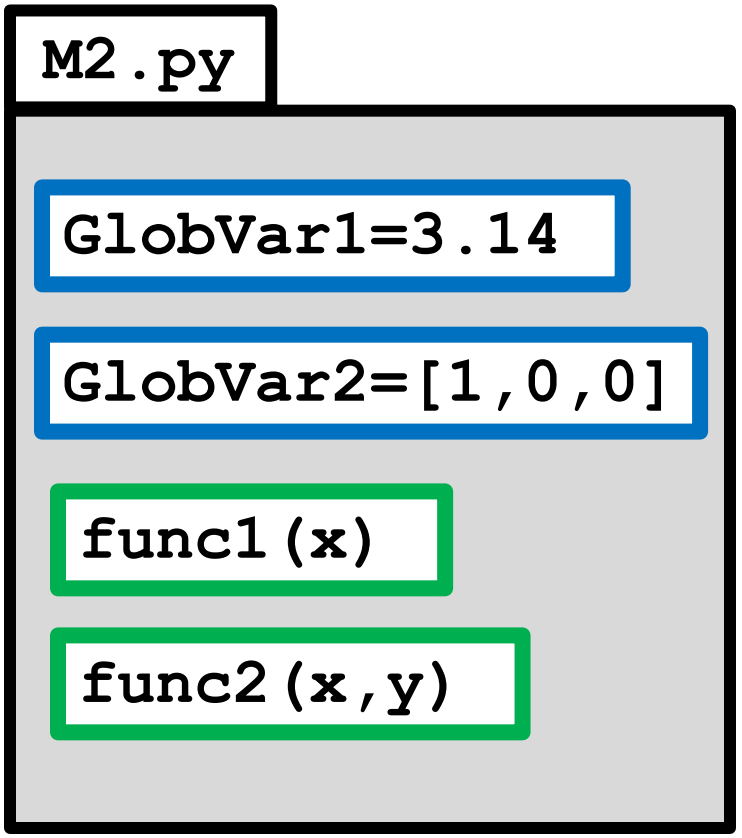


A script ▭ in `M1.py` could have a line like `a = func2(3,4)`

No dot notation

"Specific" Importing

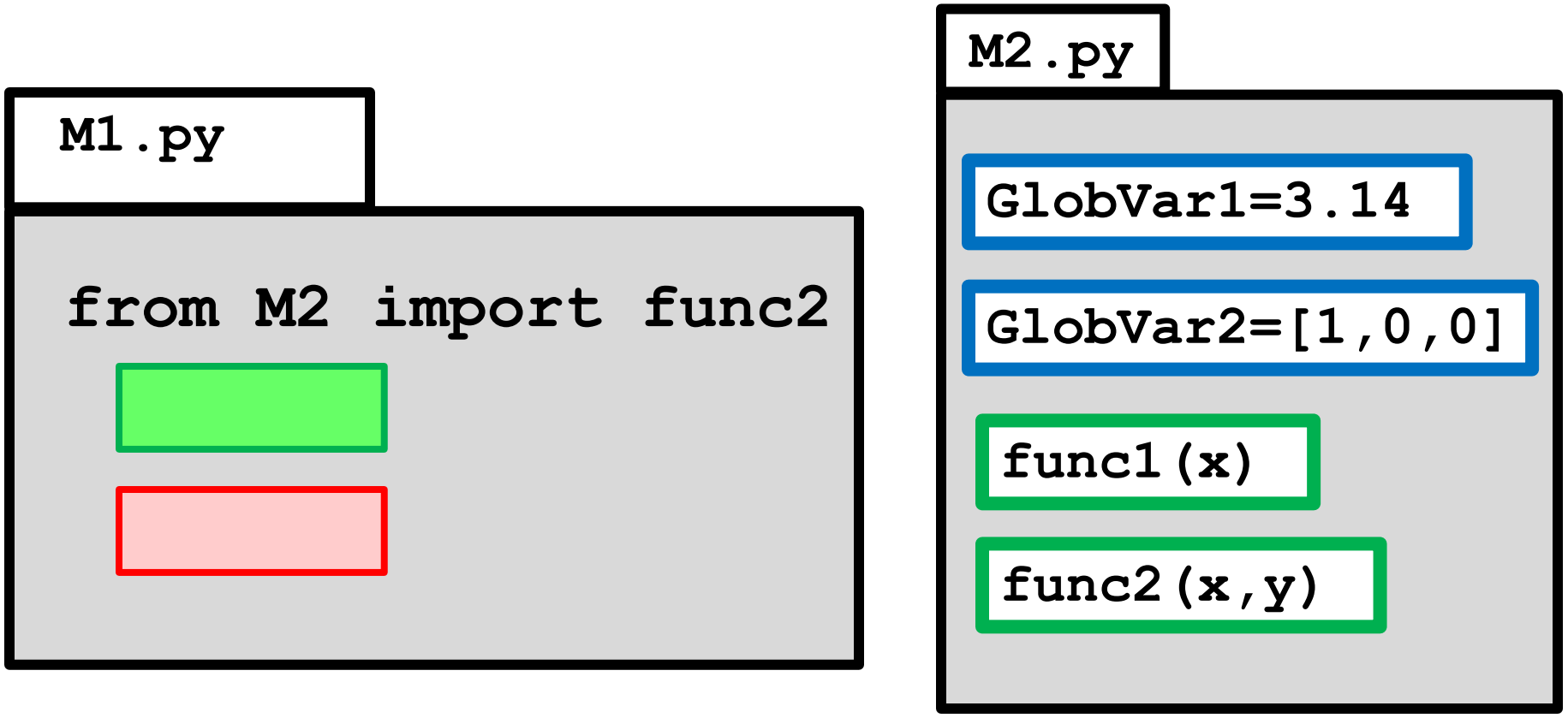




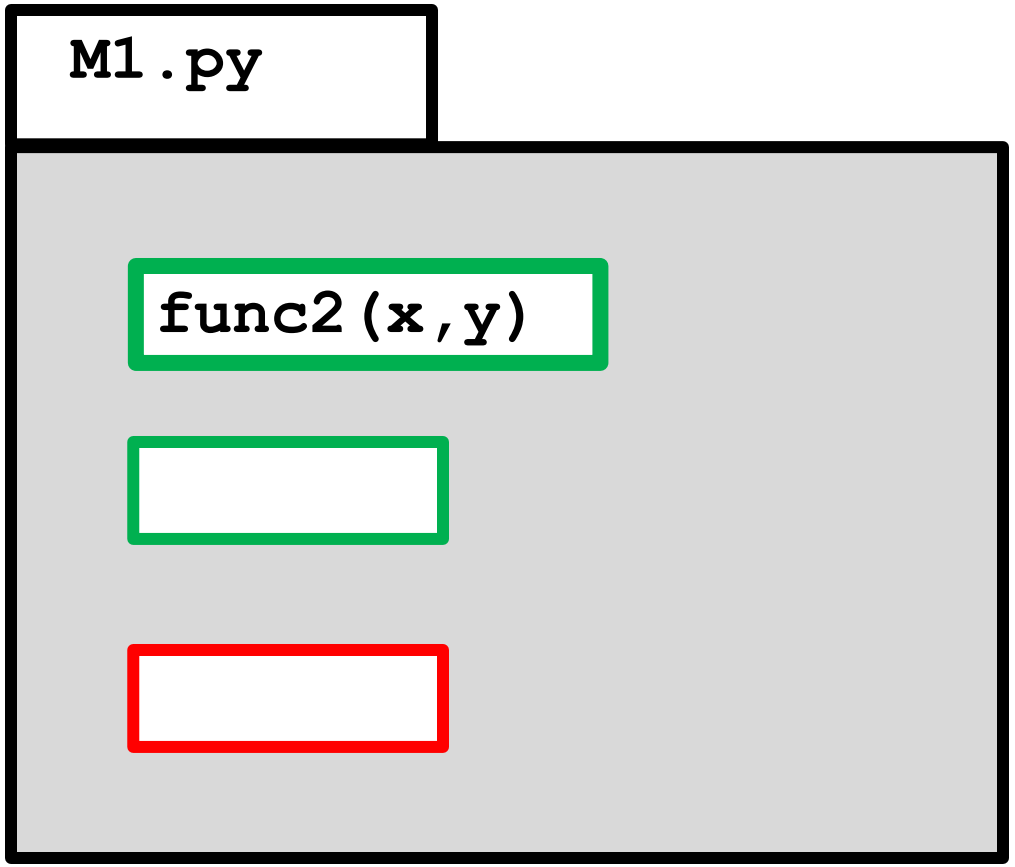
A script in `M1.py` could NOT have a line like `a = func1(4)`

No dot notation

One way to think about this…

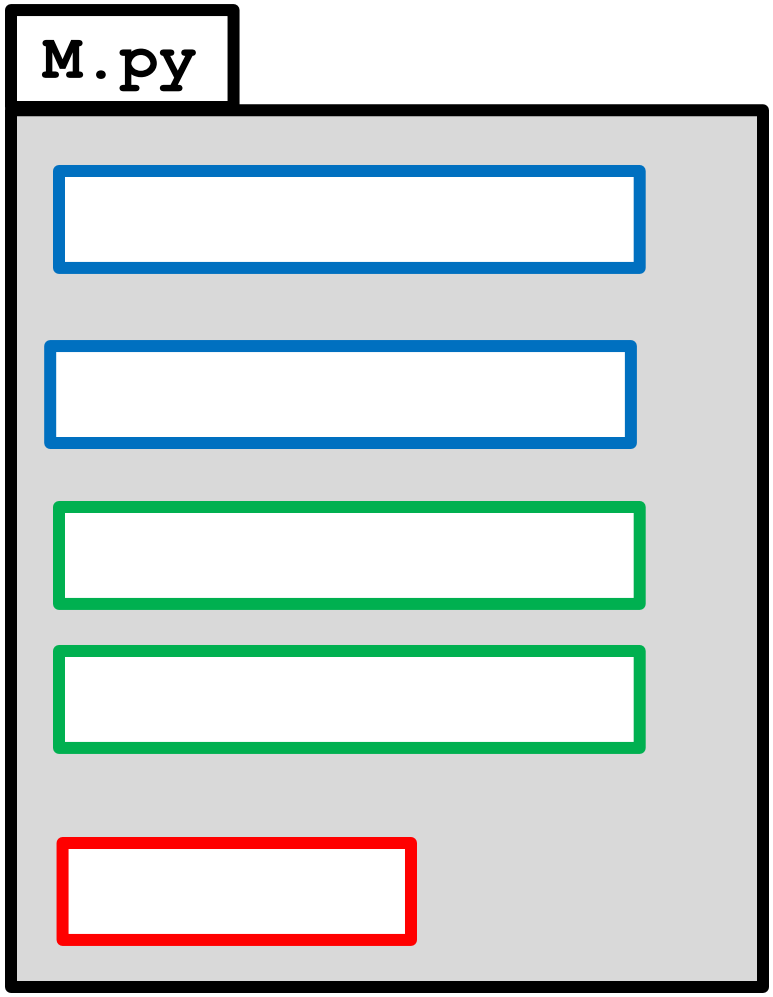


is like this…



It is as if
`func2`
was defined
in `M1.py`

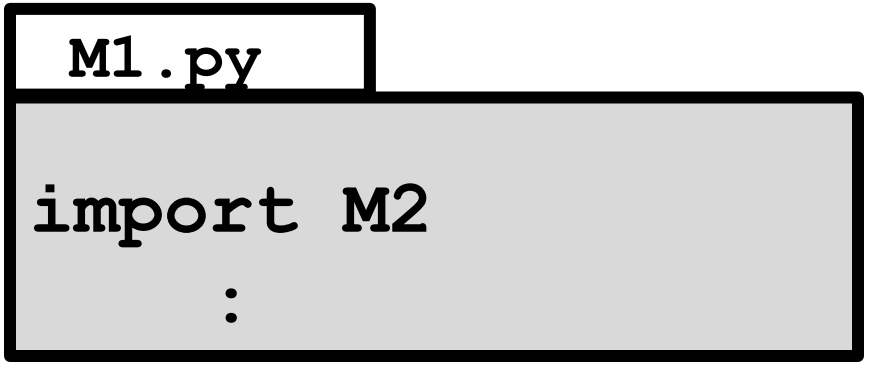
Using Stuff Within a Module



The functions and global variables in `M.py` can be used throughout `M.py` without the dot notation

There are rules about when a module `M2.py` can be imported by a module `M1.py`

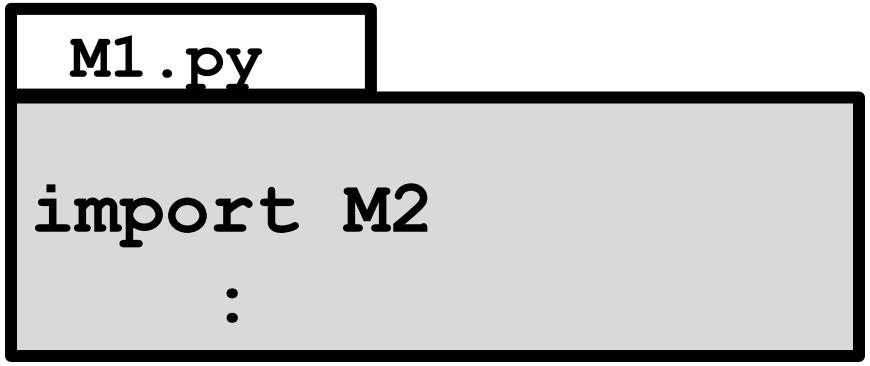
Does this Always Work?



Yes, if `M2.py` `is` a module that is part of the CS 1110 Python installation, e.g.,

`math`	`numpy`	`urllib2`	`string`
`scipy`	`PIL`	`random`	`timeit`

Does this Always Work?



No UNLESS **`M1.py`** and **`M2.py`** are each in the "current working directory".

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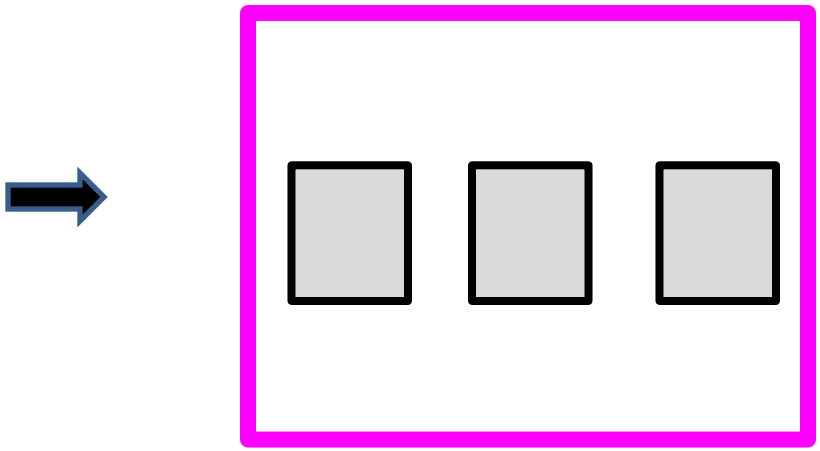
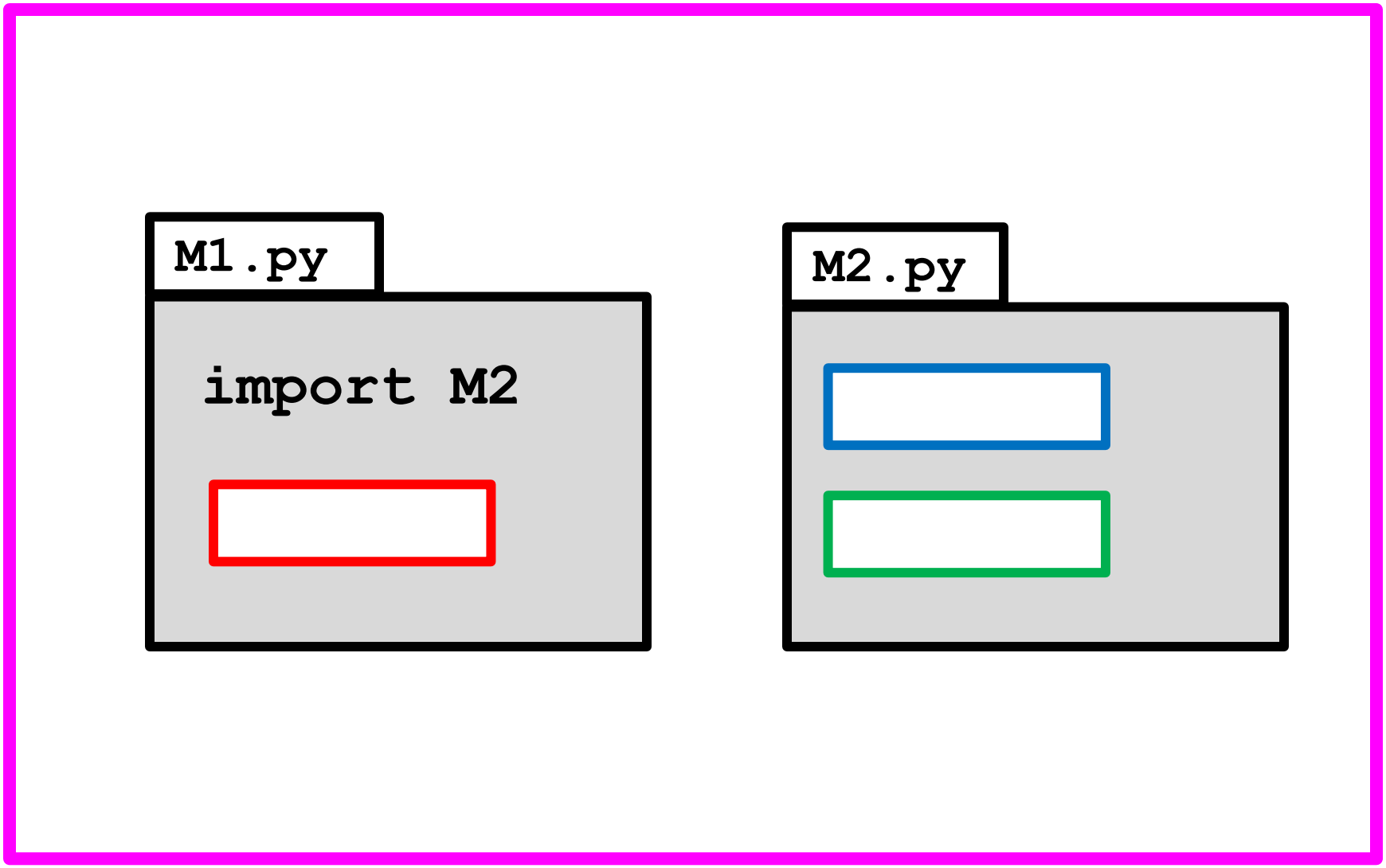
Comments on "Launching" a Python Computation

In what follows, this will be how we indicate what's in the "current working directory"

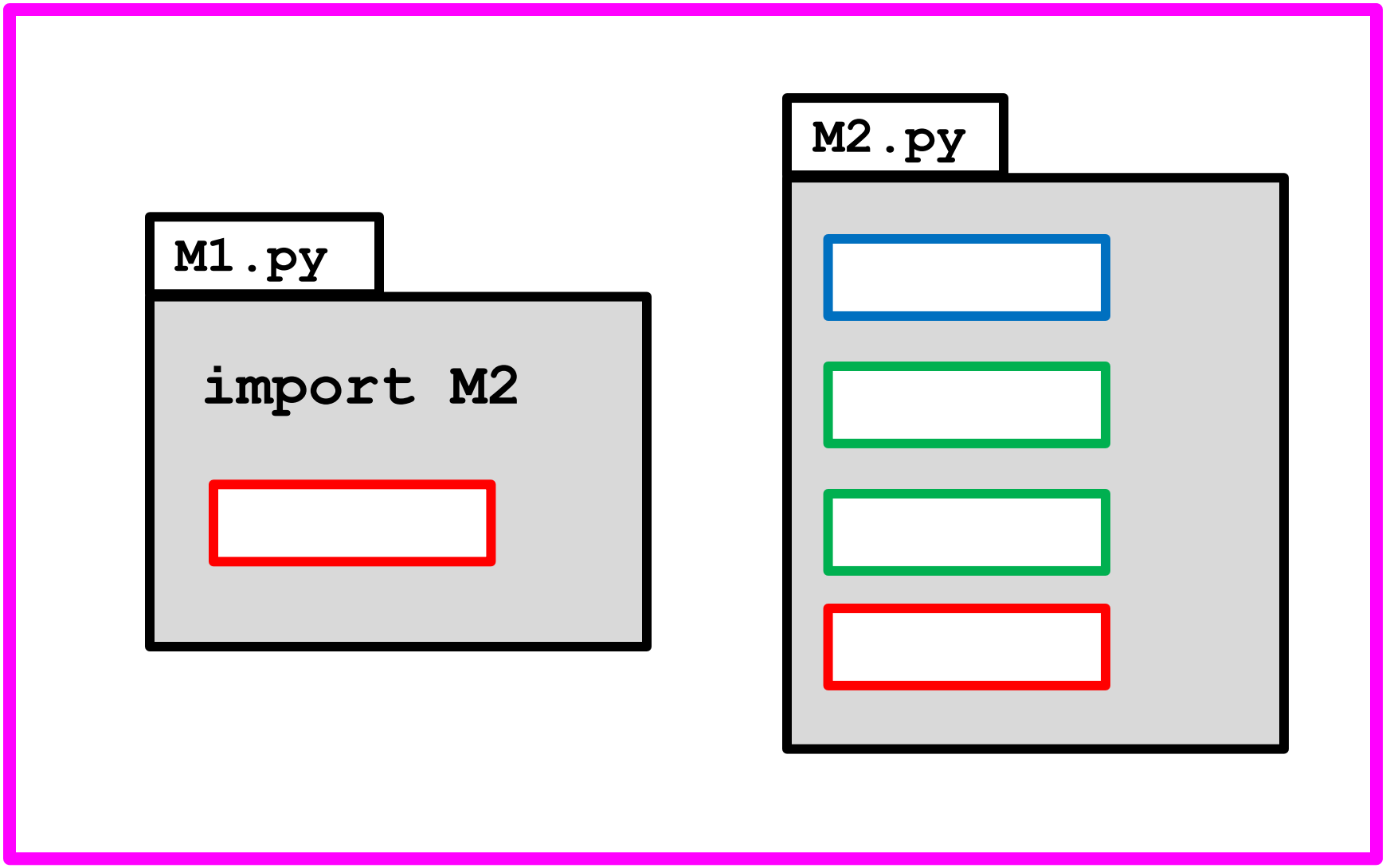


And this will mean we are in the command shell and in the "current working directory"




```
cwd > python M1.py
```

The script in `M1.py` is executed

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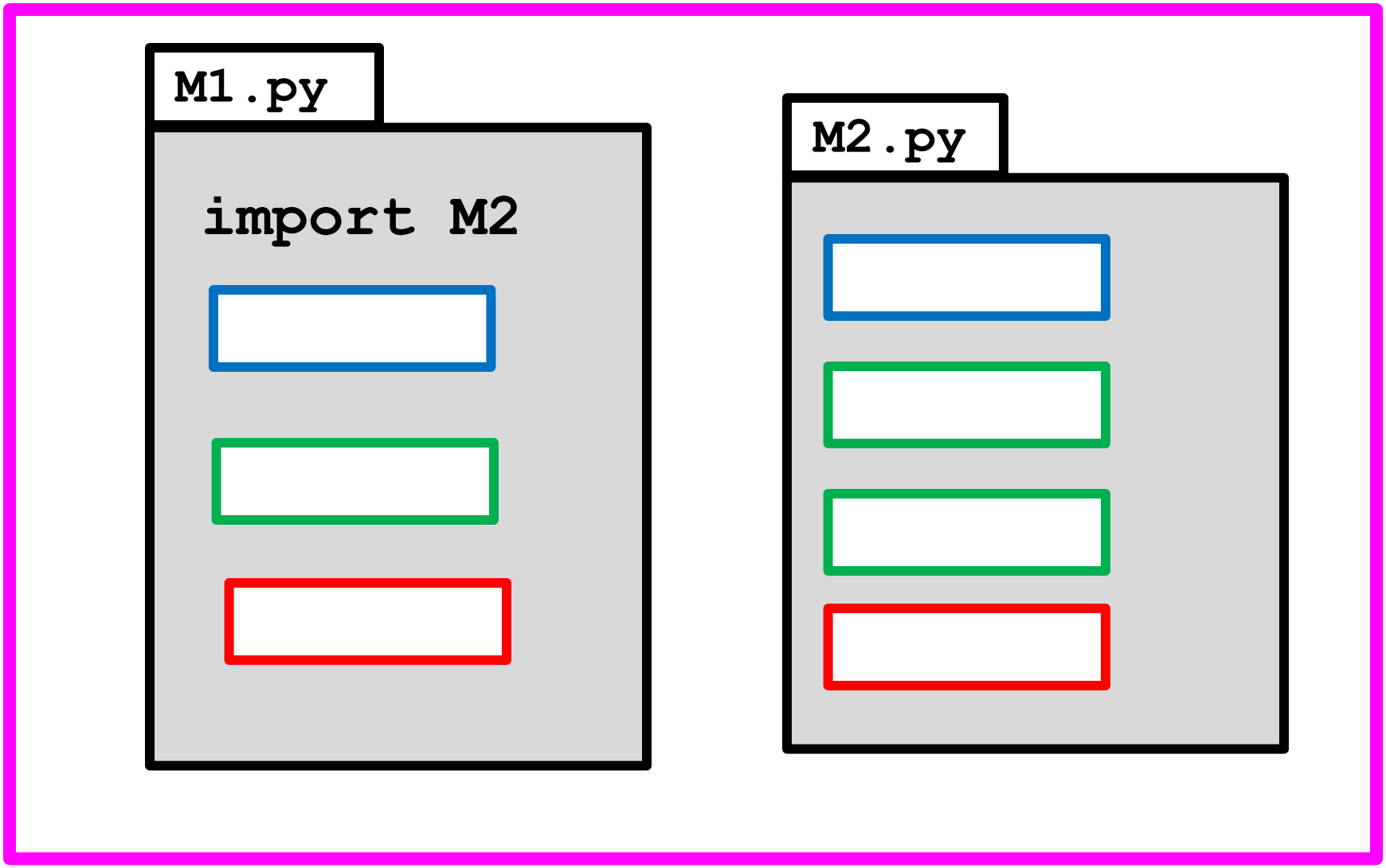


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cwd > python M1.py
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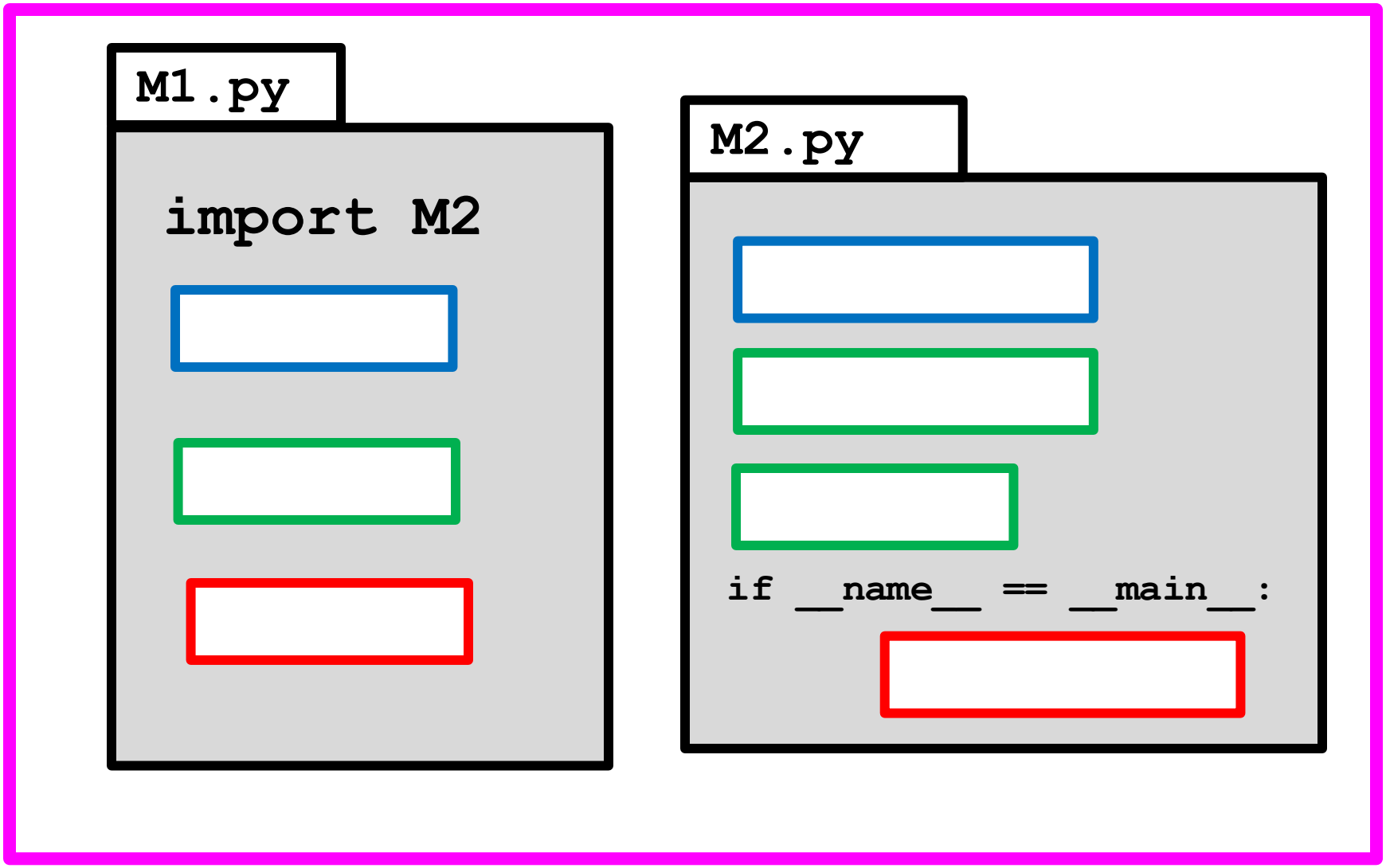
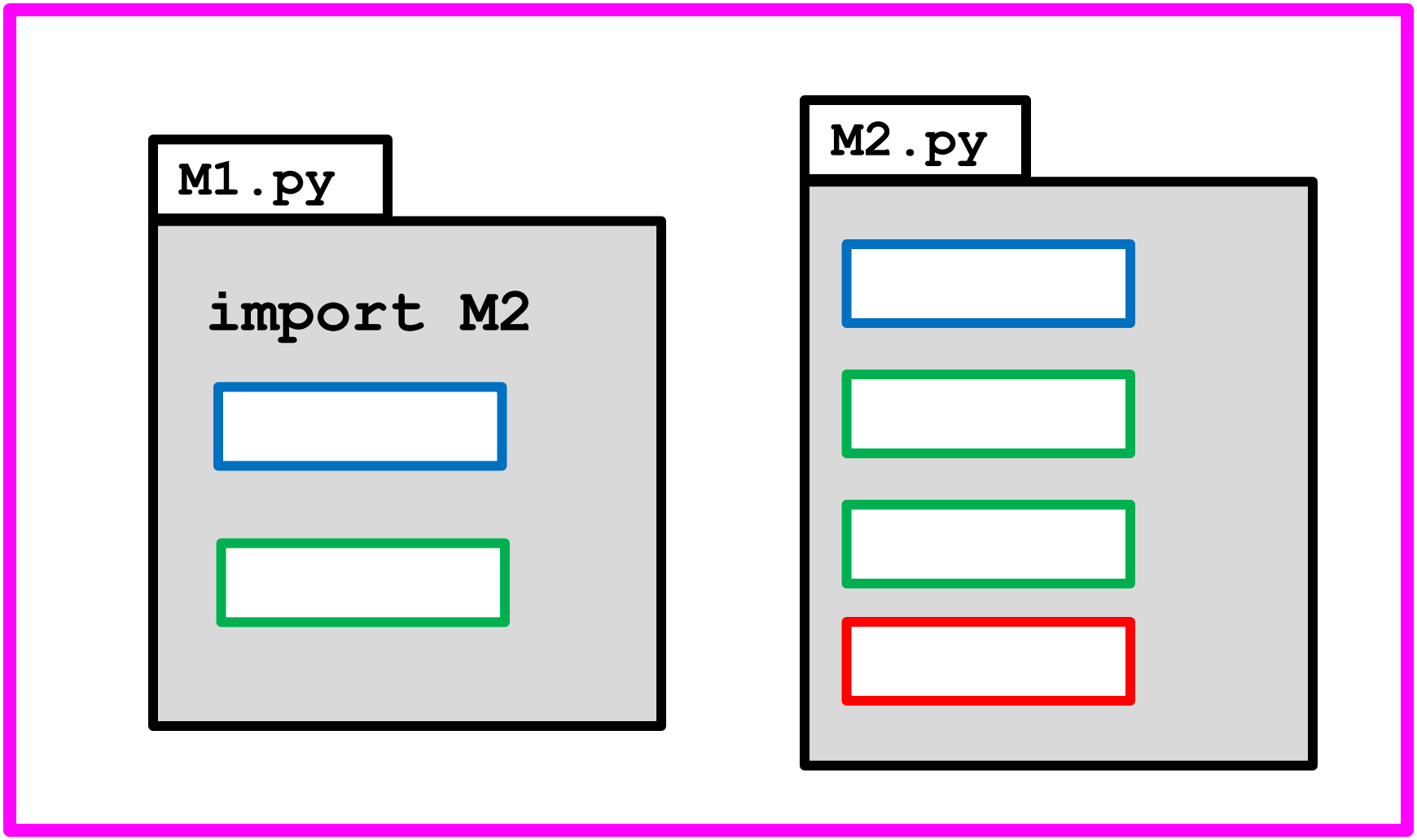
The script in `M1.py` is executed




```
cwd > python M1.py
```

The script in `M2.py` is NOT executed




```
cwd > python M1.py
```

Nothing happens because there is no script in `M1.py` to execute.

Important Distinction

Distinguish between calling a function

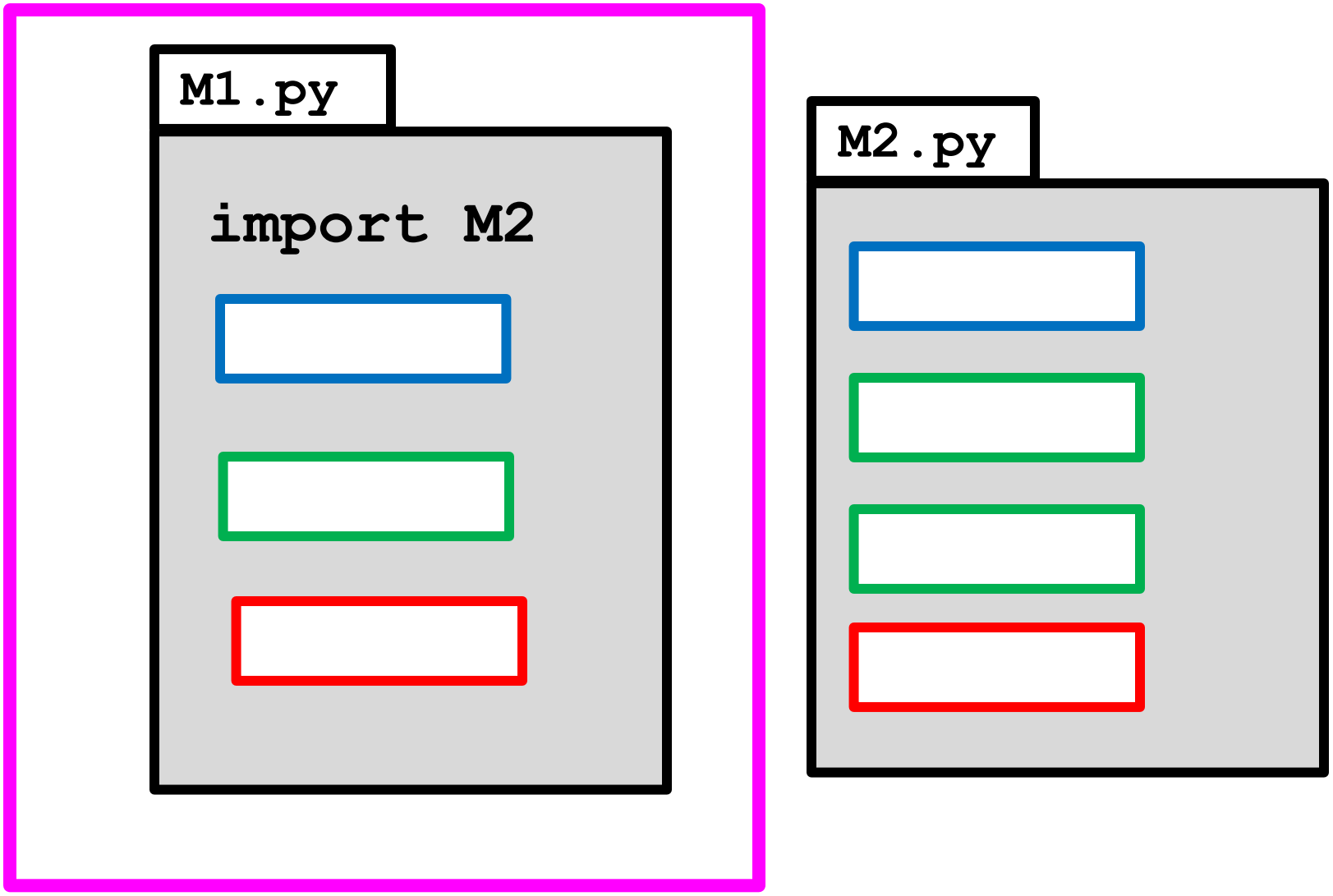
```
y = sqrt(3)
```

and defining a function

```
def sqrt(x):
    L = x
    L = (L + x/L)/2
    L = (L + x/L)/2
    return L
```

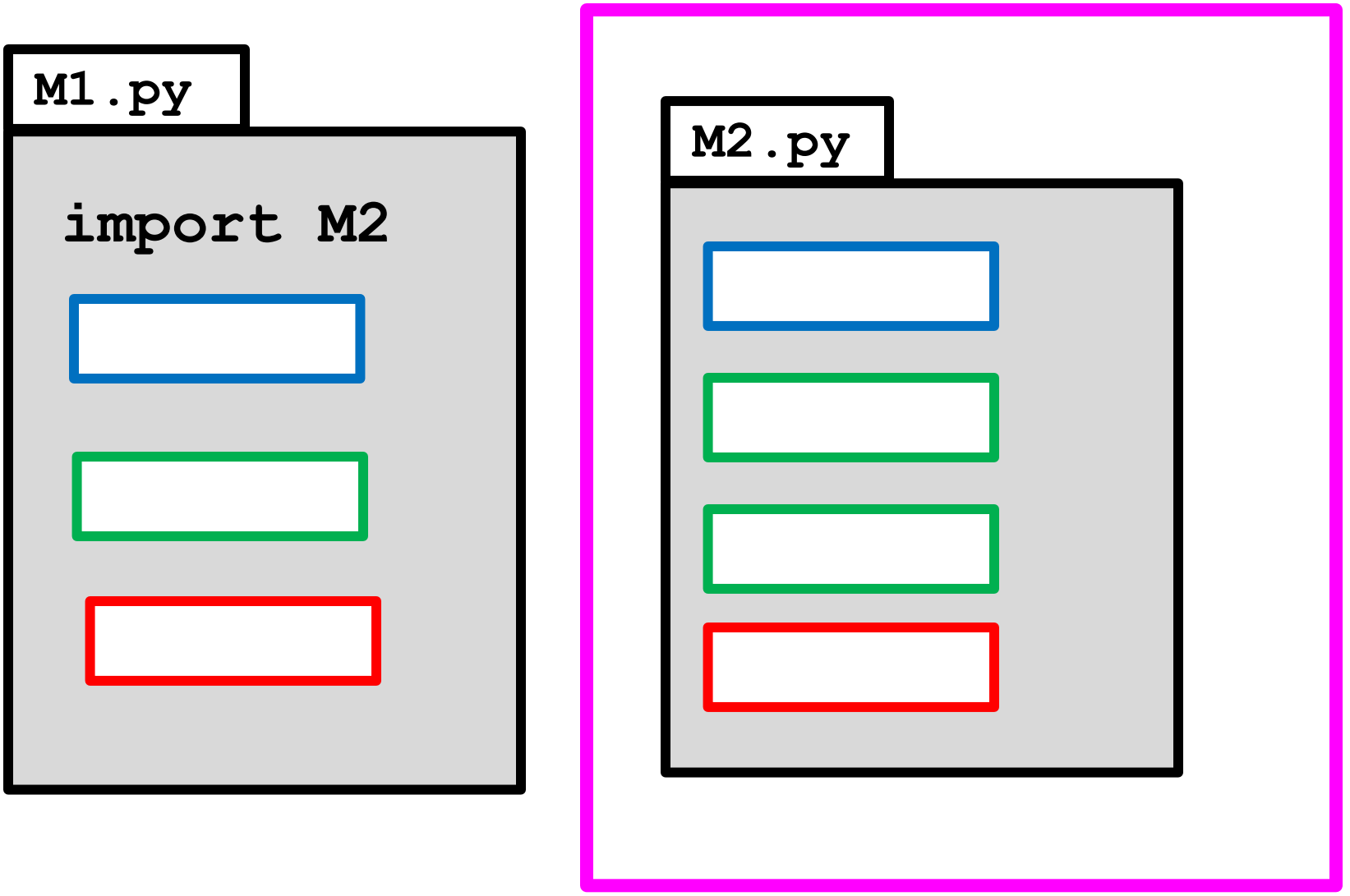
A function isn't executed when it is defined.

Think of defining a function as setting up a formula that is to be used later.



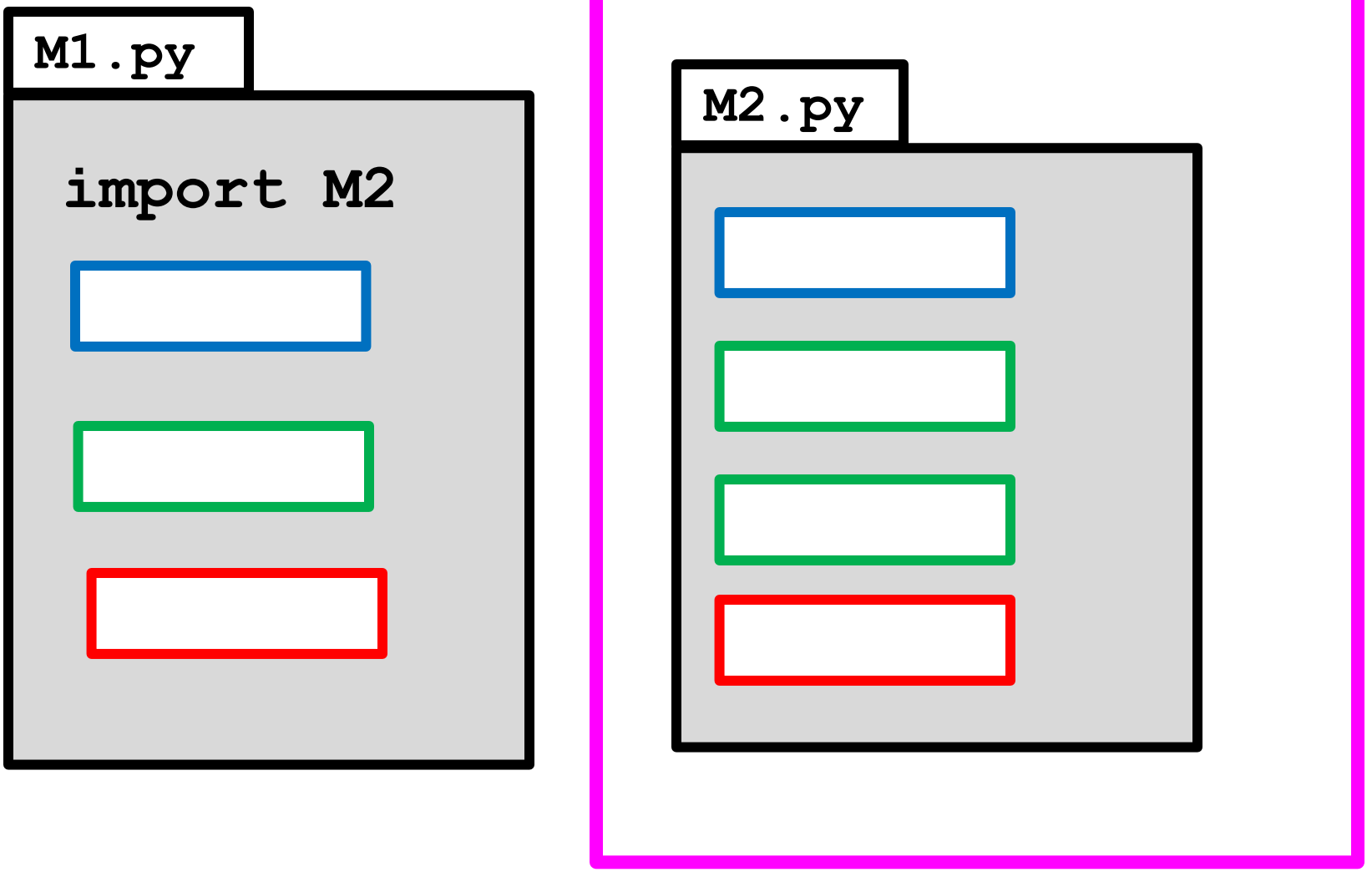

```
cwd > python M1.py
```

Error. Python cannot find M2




```
cwd > python M1.py
```

Error. Python cannot find M1




```
cwd > python M2.py
```

Fine. M2.py does not need M1.py

We now focus our attention on the mechanics behind function calls.

Somewhat Like Plugging into a Formula

For the simple kind of fruitful functions that we have been considering, there is a substitution process.

Exactly how does it work?

We Use This Example…

```
def T(s):
""" Returns as int the number of minutes
from 12:00 to the time specified by s.

PreC: s is a length-5 string of the form
'hh:mm' that specifies the time."""

    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

A Script

function call

function call

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
```

This assigns to **numMin** the number of minutes in a class that starts at the time specified by **s1** and ends at the time specified by **s2**.

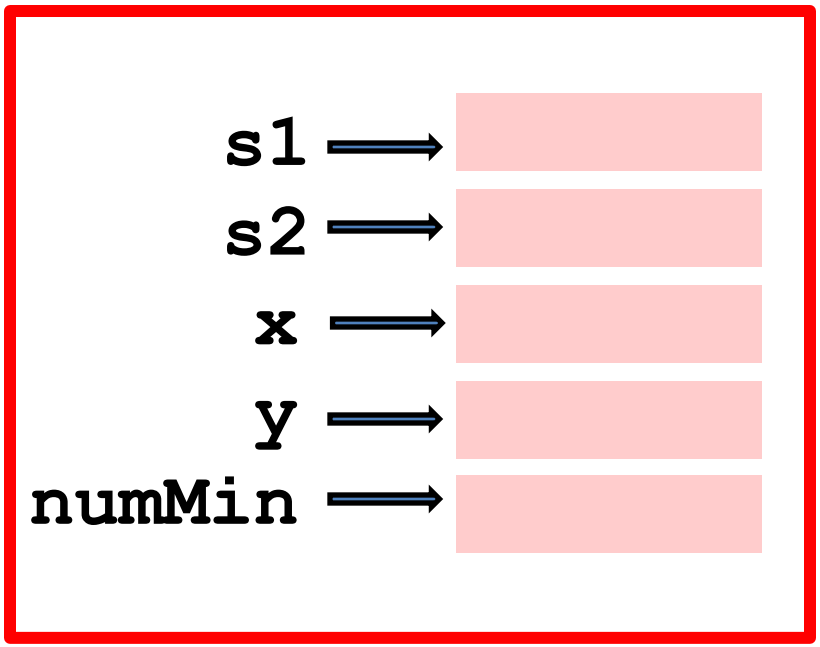
A Script

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

Prints the number of minutes in a class that starts at the time specified by **s1** and ends at the time specified by **s2**. Let us step through its execution.

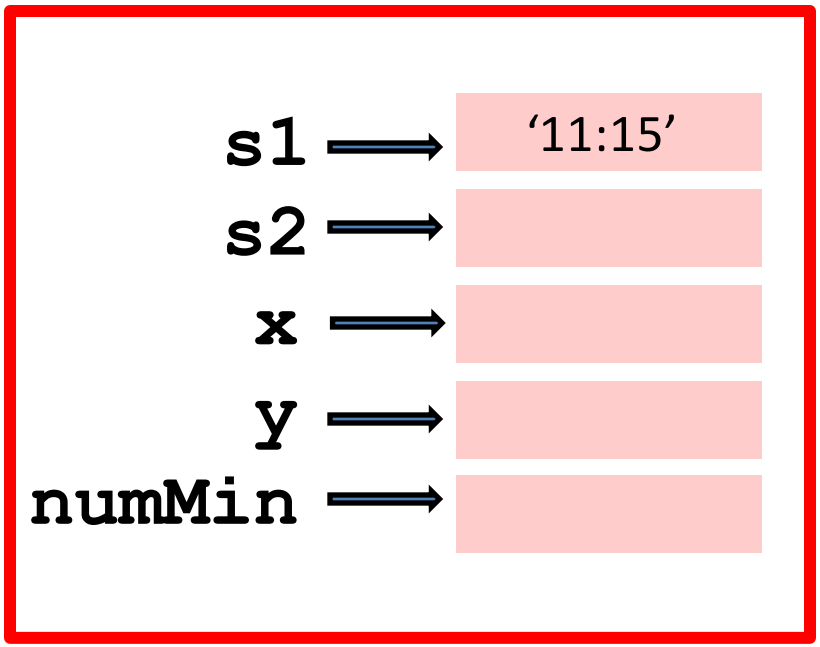
```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

The red dot indicates the next thing to do in the script.



This box is called Global Space. It includes all the variables associated with the script.

```
 s1 = '11:15'
s2 = '12:05'
 x = T(s1)
 y = T(s2)
 if y>=x:
     numMin = y-x
 else:
     numMin = (y+720)-x
 print numMin
```



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print numMin
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```
def T(s):
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    if h<12:
        z = 60*h+m
    else:
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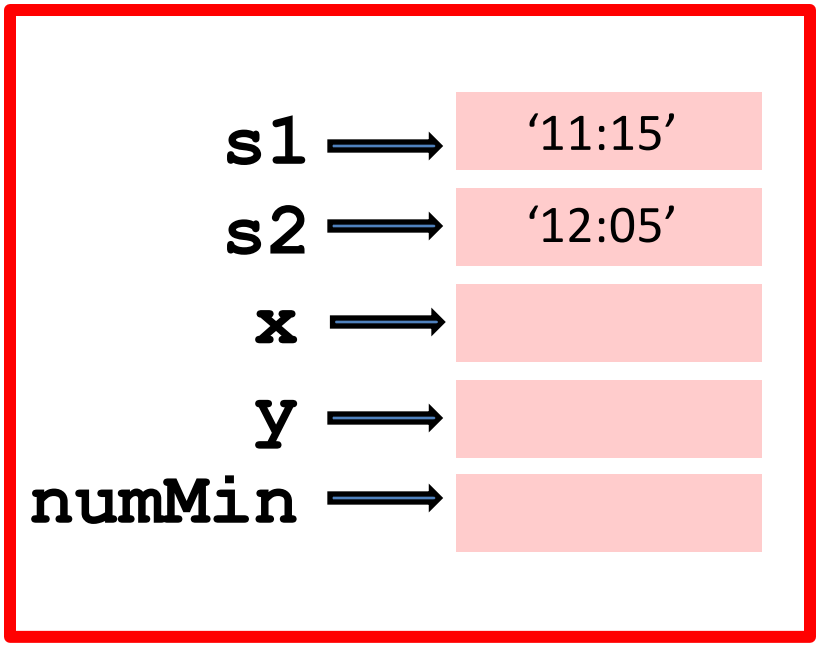
    return z
```



Function call

We open up a "call frame" that shows the "key players" associated with the function

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
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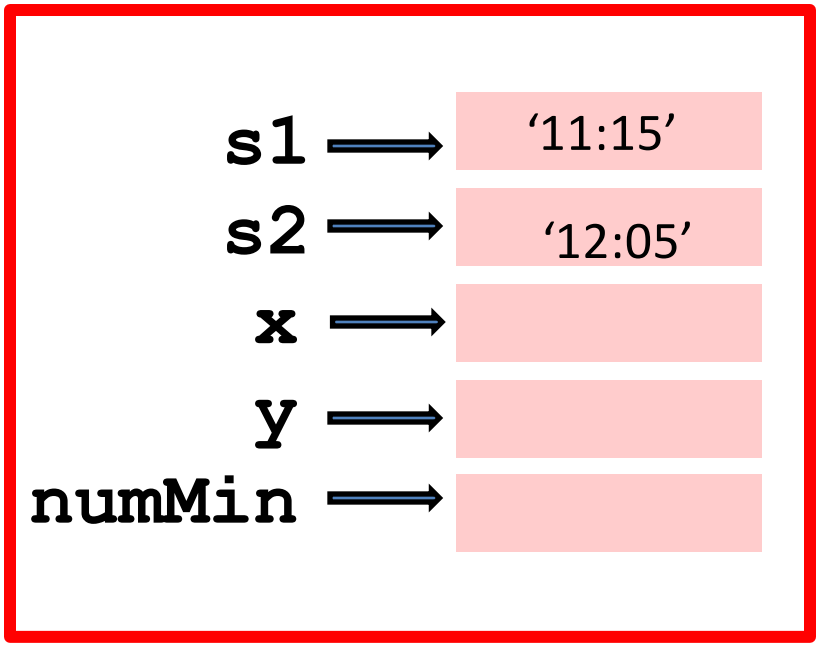

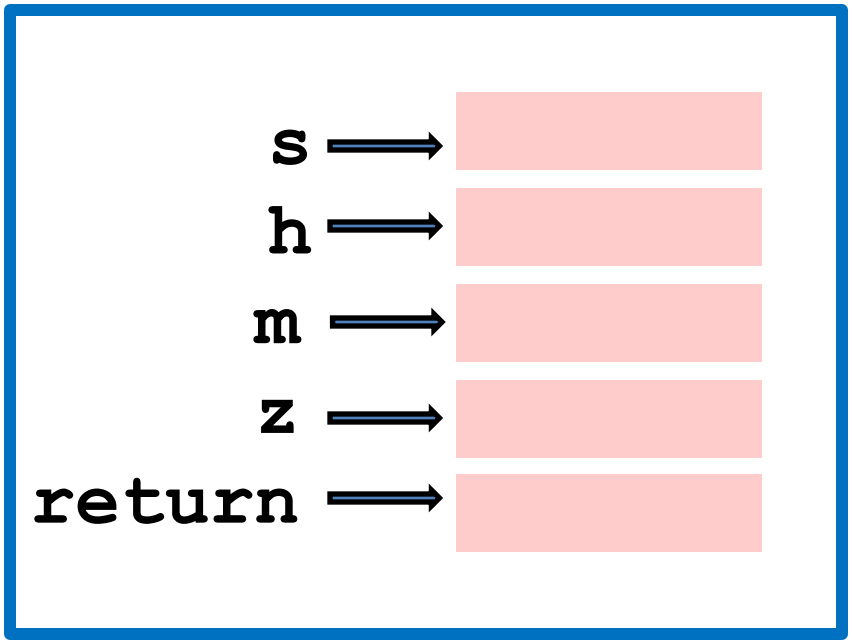

The variable s is the function's parameter

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
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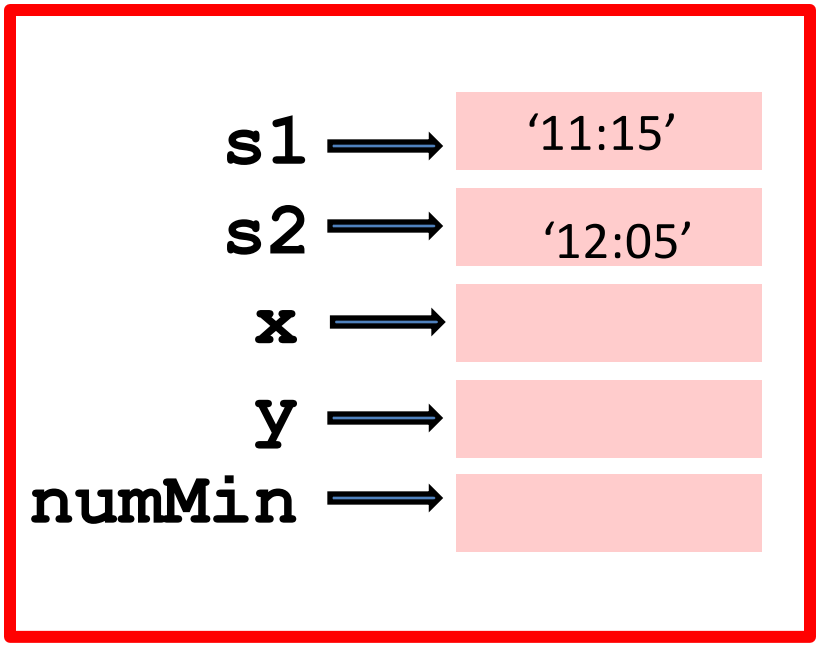
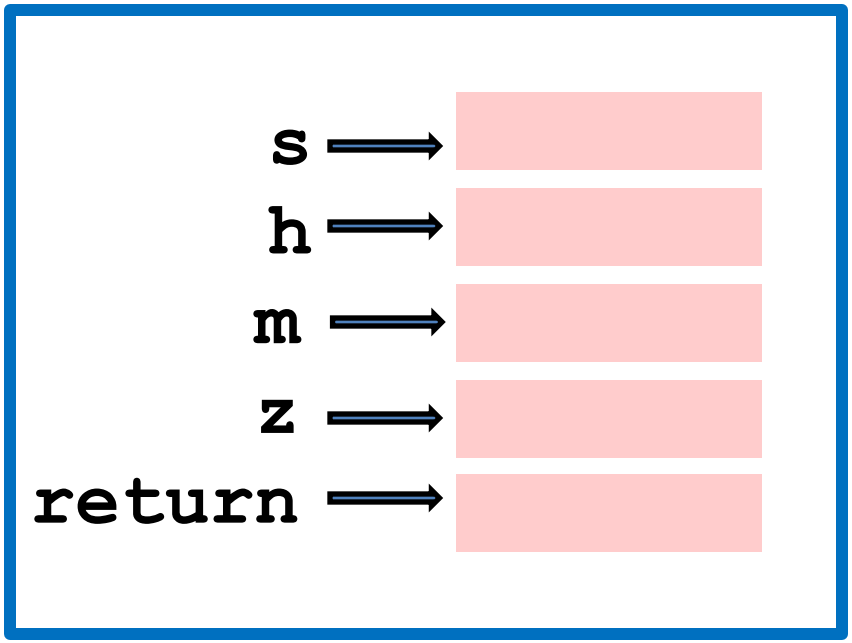
```

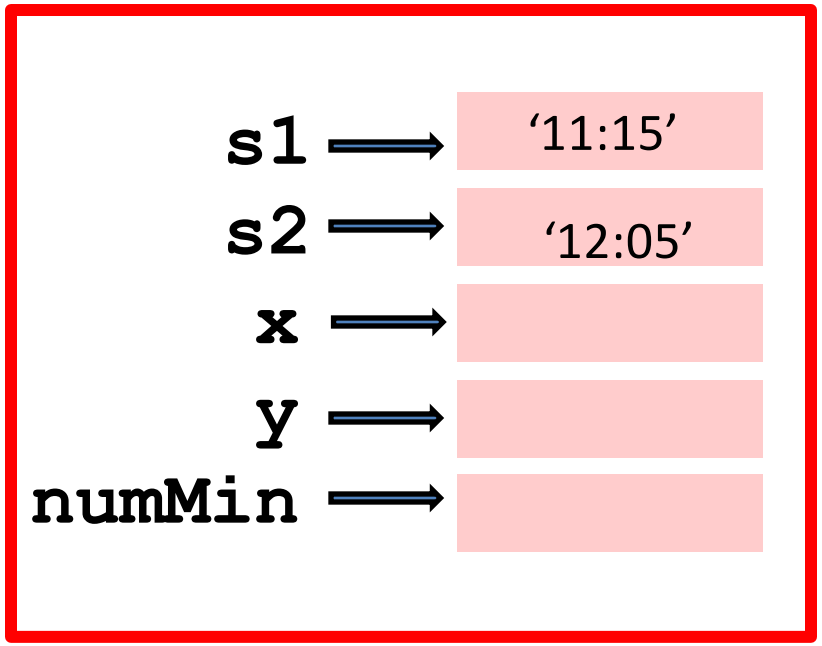


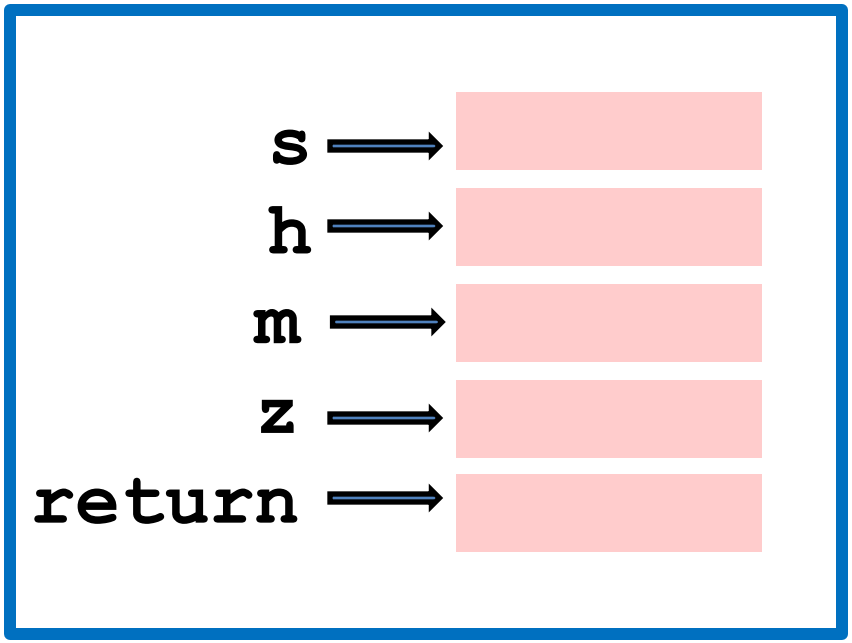


The variables `h`, `m`, and `z` is the function's local variables

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

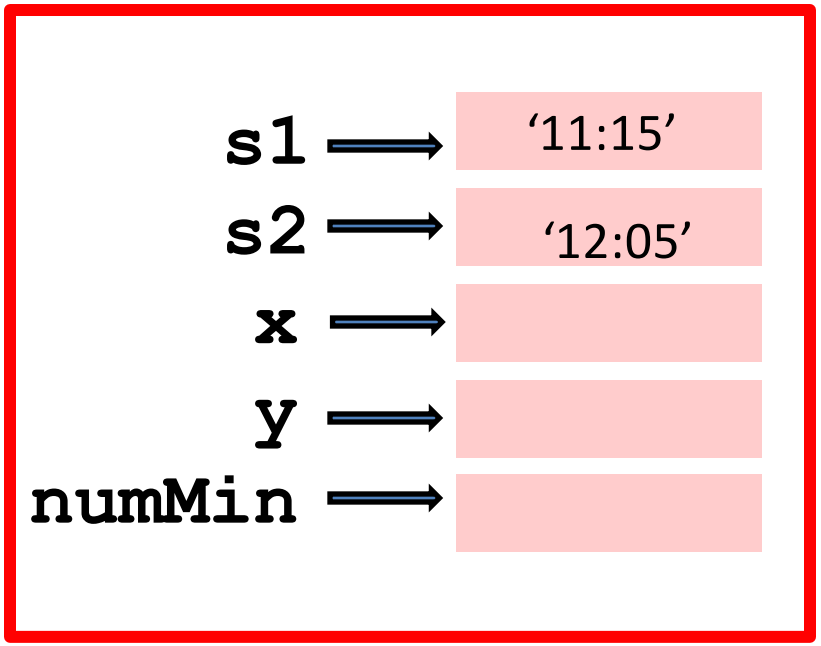


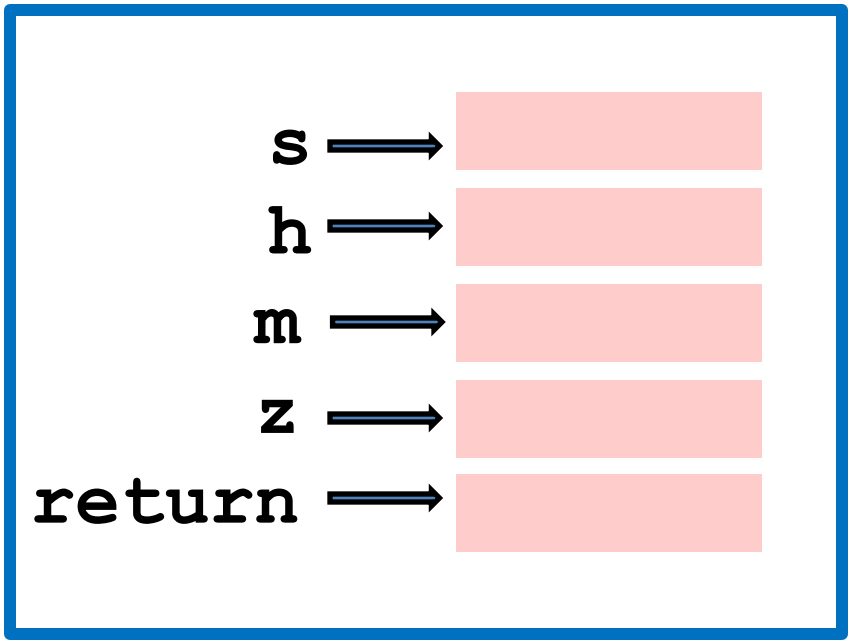


return is a special variable. Will house the value to return

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

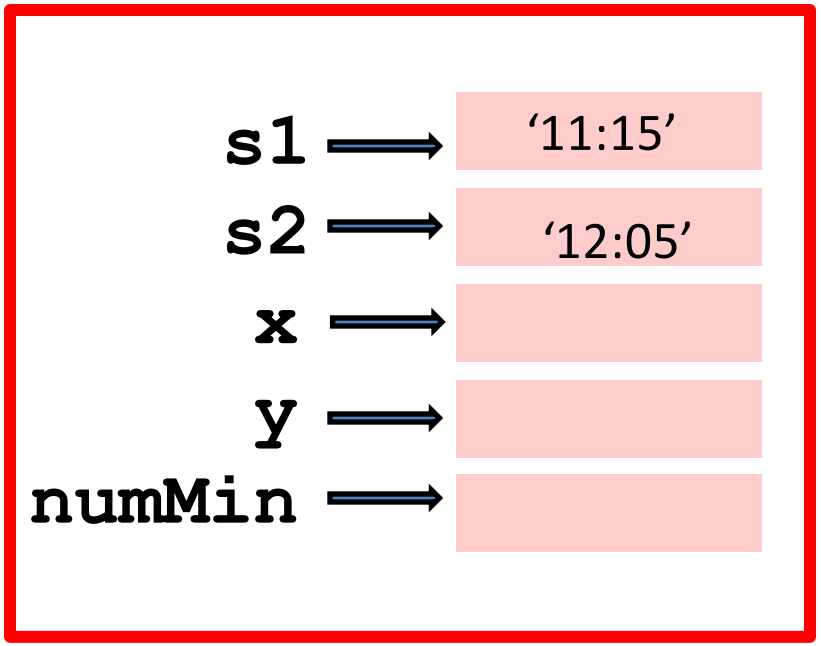


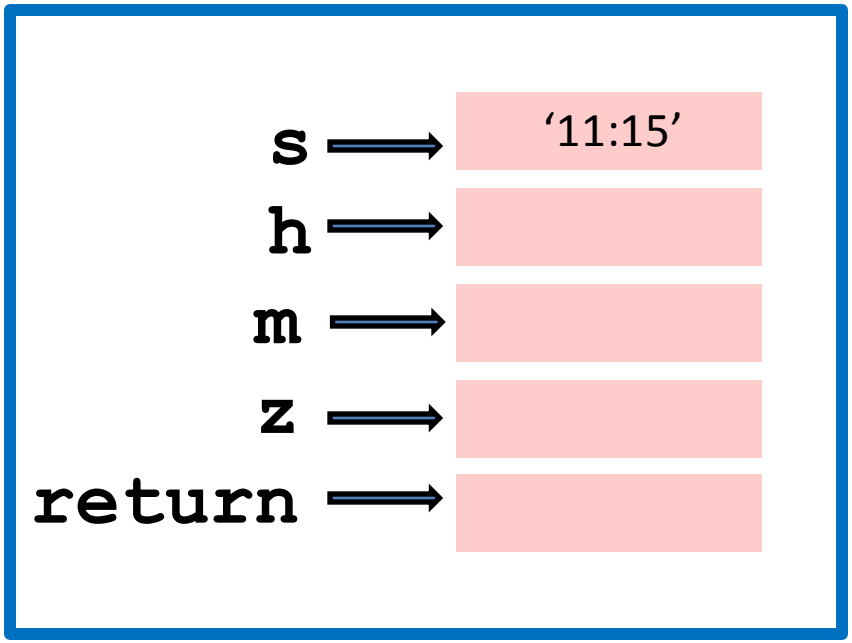


Control passes from the red dot to the blue dot

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

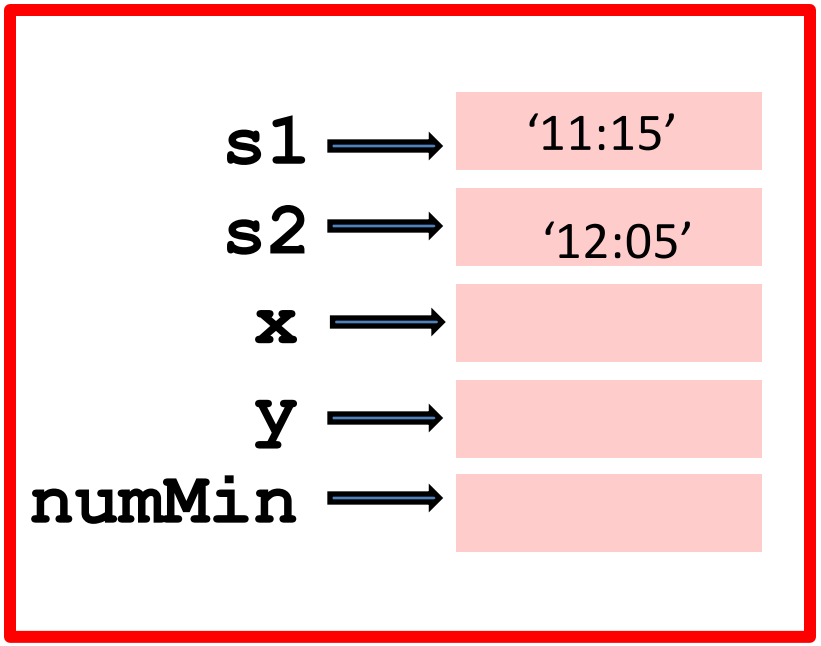


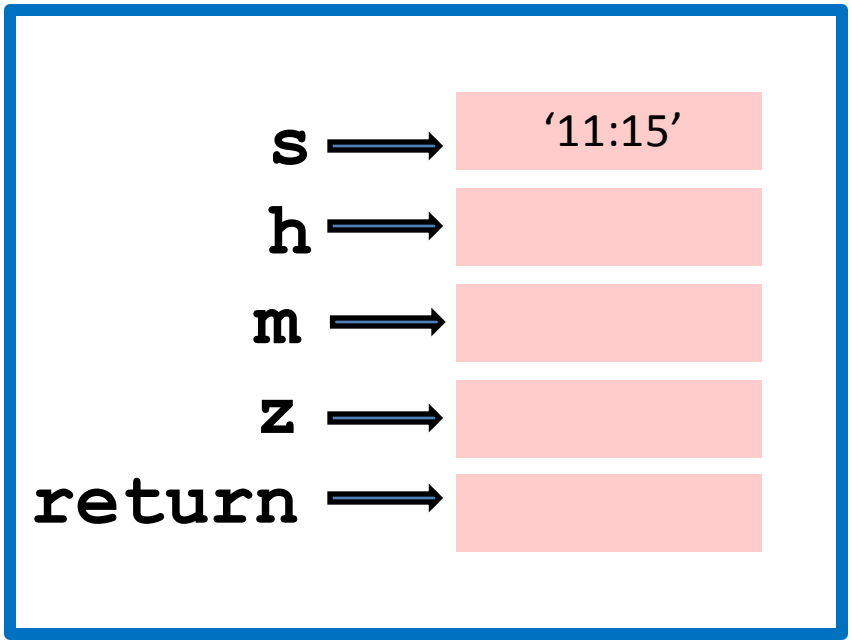


Assign the argument value (housed in s1) to the parameter s.

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

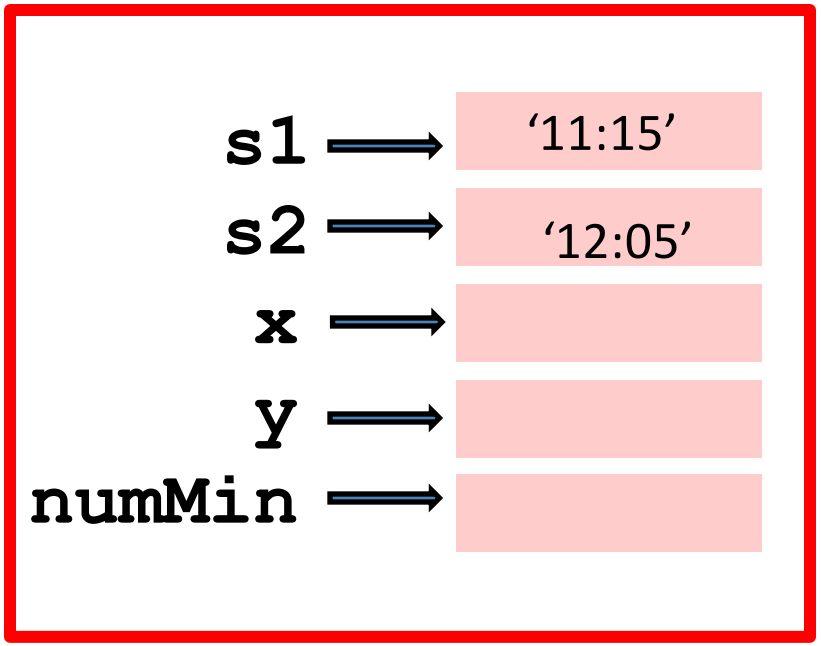


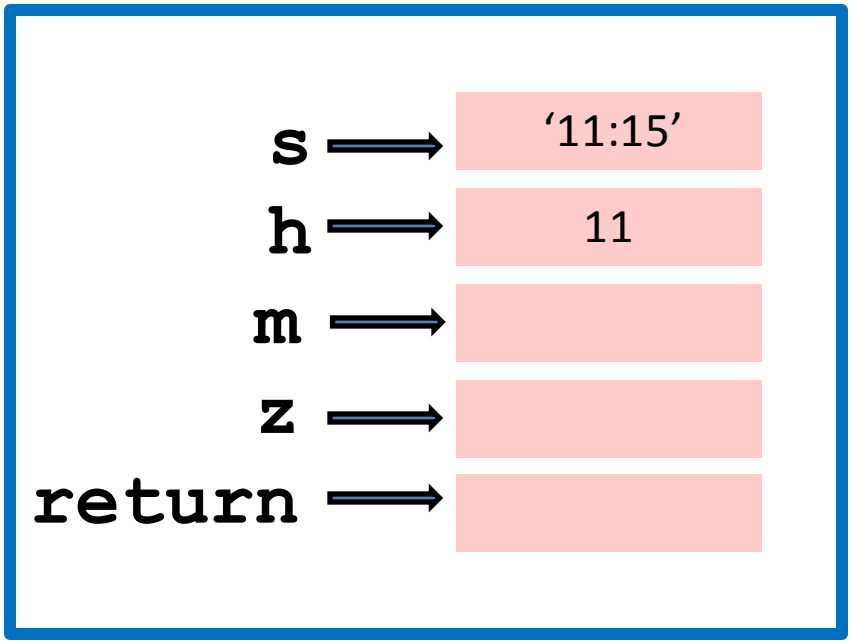


Assign the argument value (housed in s1) to the parameter s.

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```





We step through the function body. Business as usual.

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

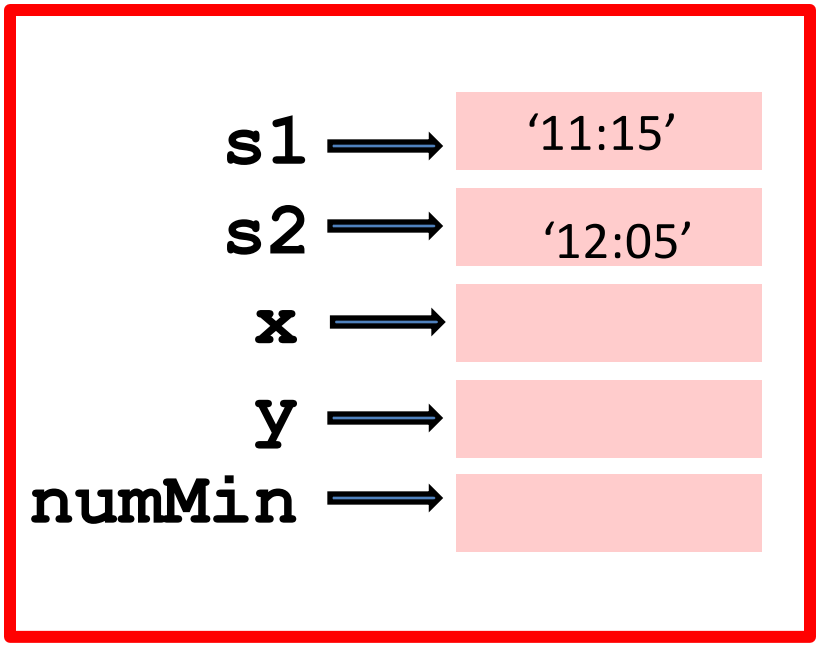
s1	'11:15'
s2	'12:05'
x	
y	
numMin	

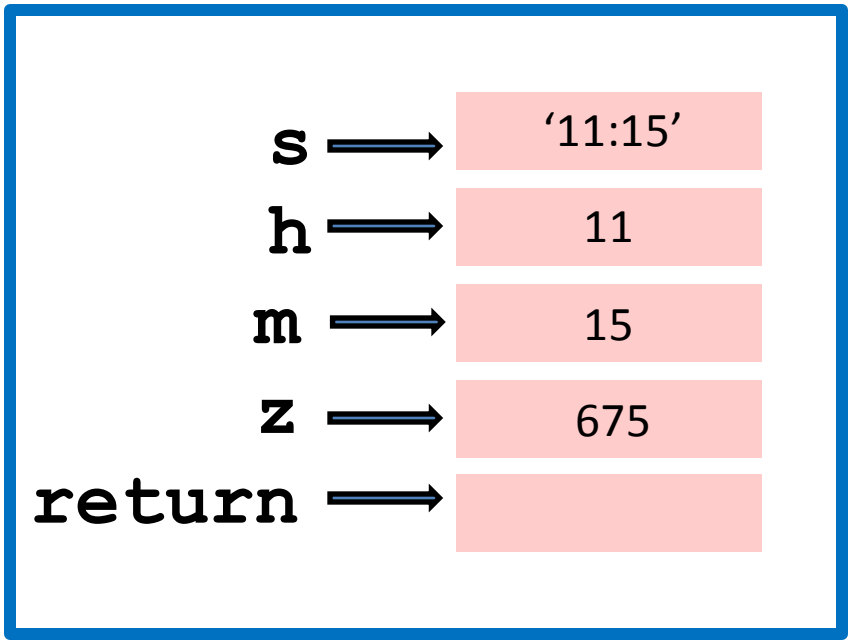
s	'11:15'
h	11
m	15
z	
return	

We step through the function body. Business as usual.

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```





We step through the function body. Business as usual.

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

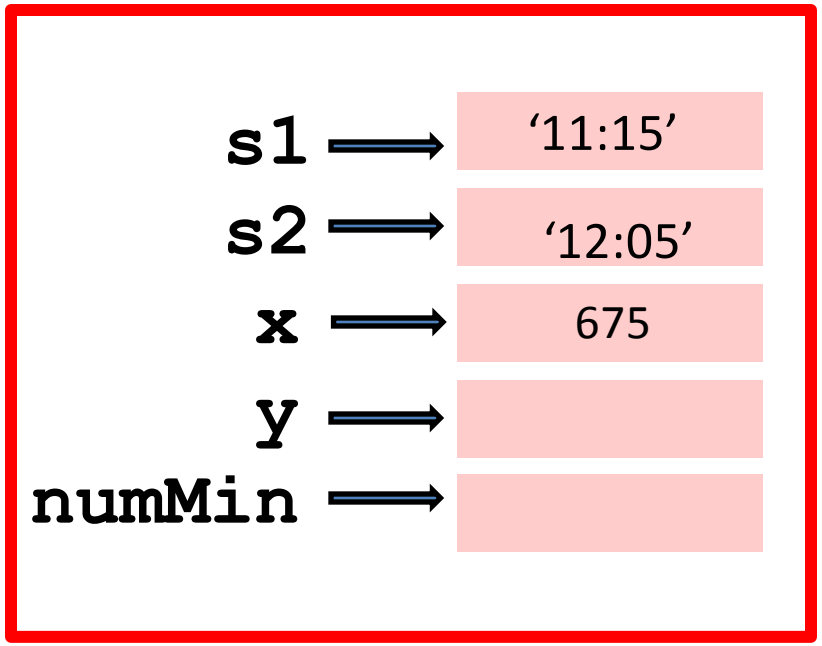
s1	'11:15'
s2	'12:05'
x	675
y	
numMin	

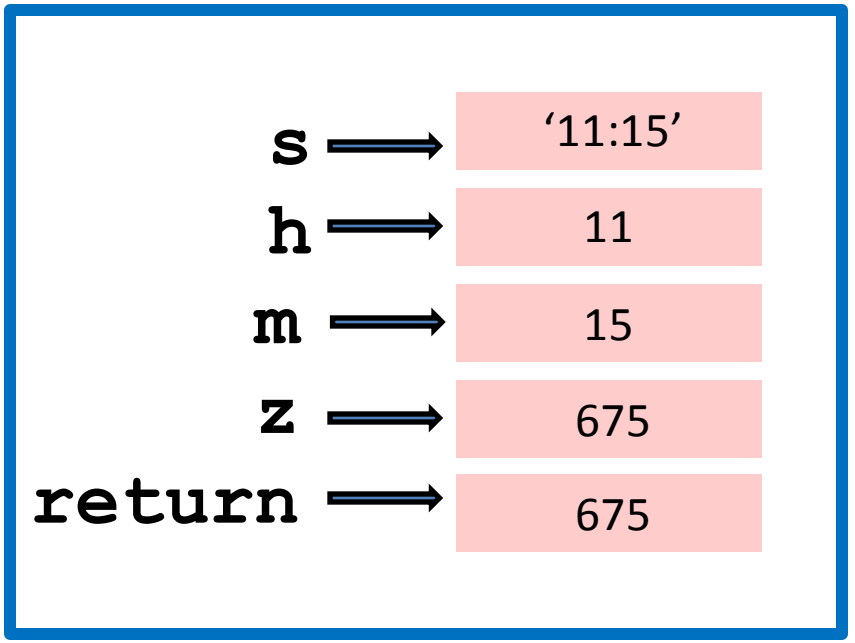
s	'11:15'
h	11
m	15
z	675
return	675

The return value is shipped back the to red dot instruction.

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

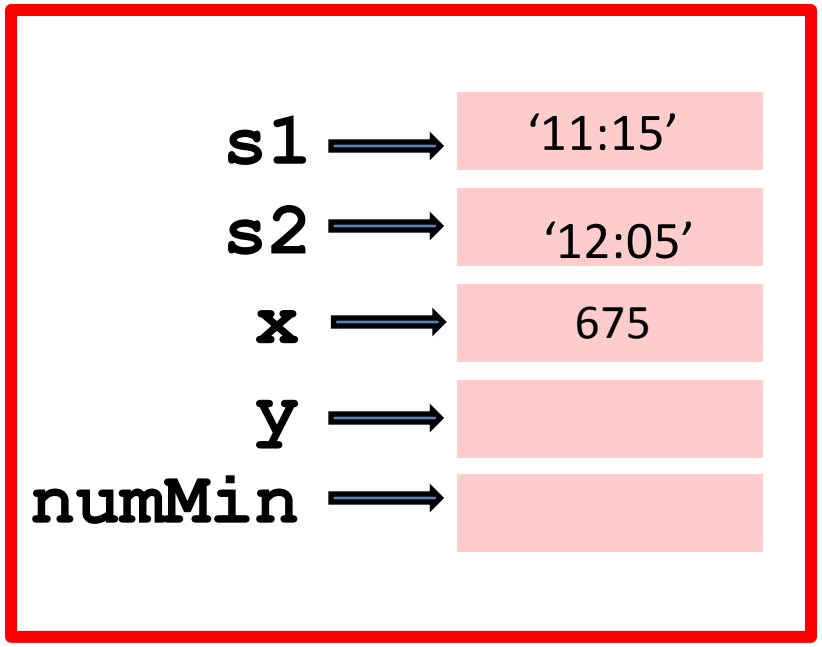
```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```





The function call is over. The Call Frame "disappears"…

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

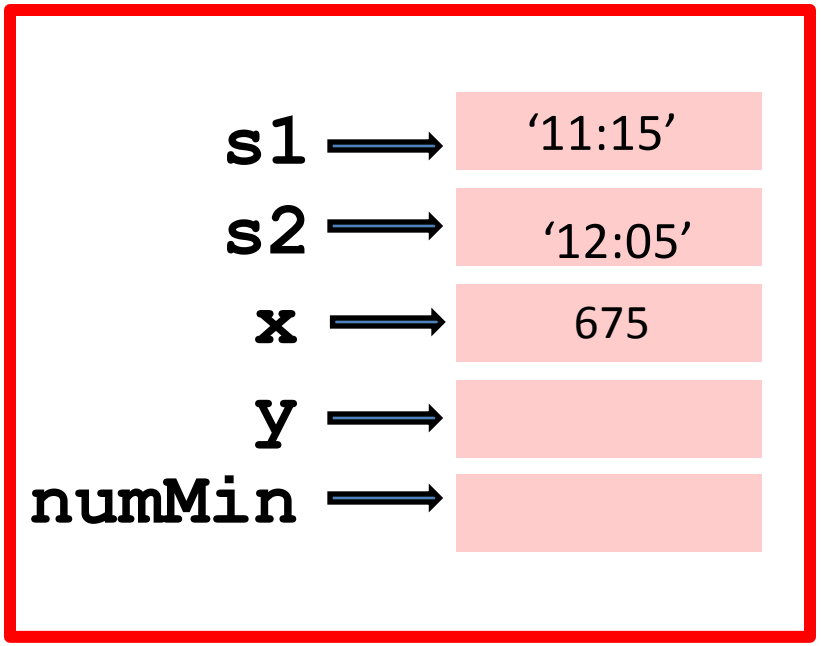


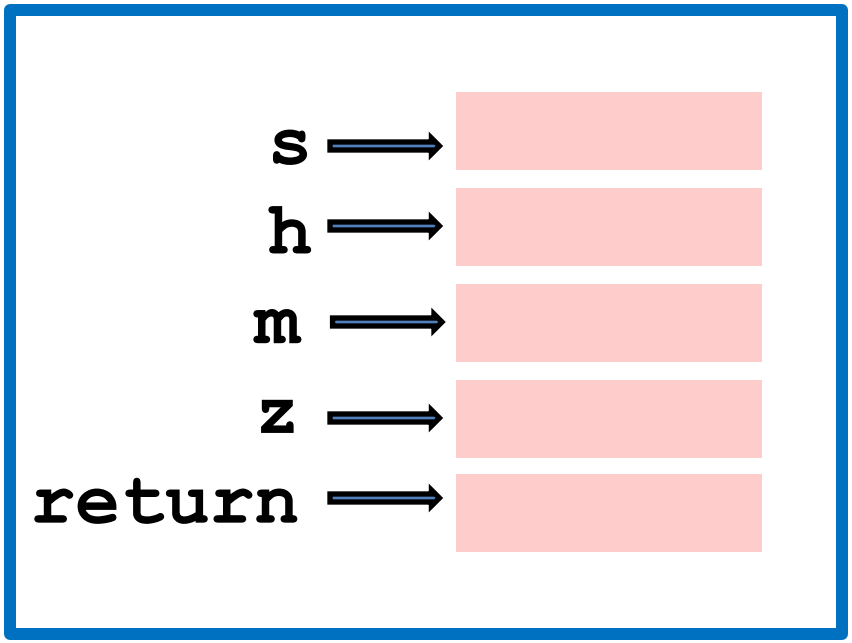
Another function Call!

And the red dot moves to the next statement in the script

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

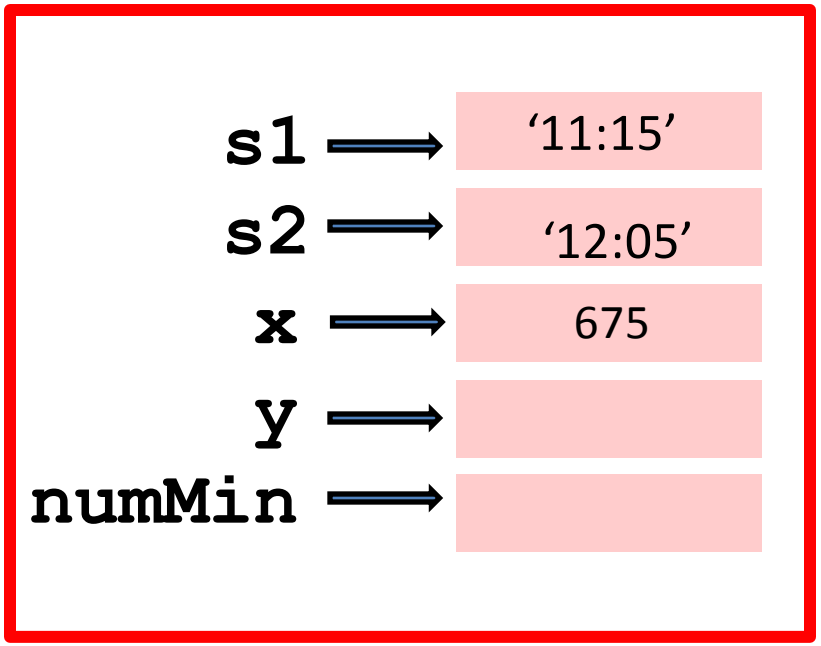


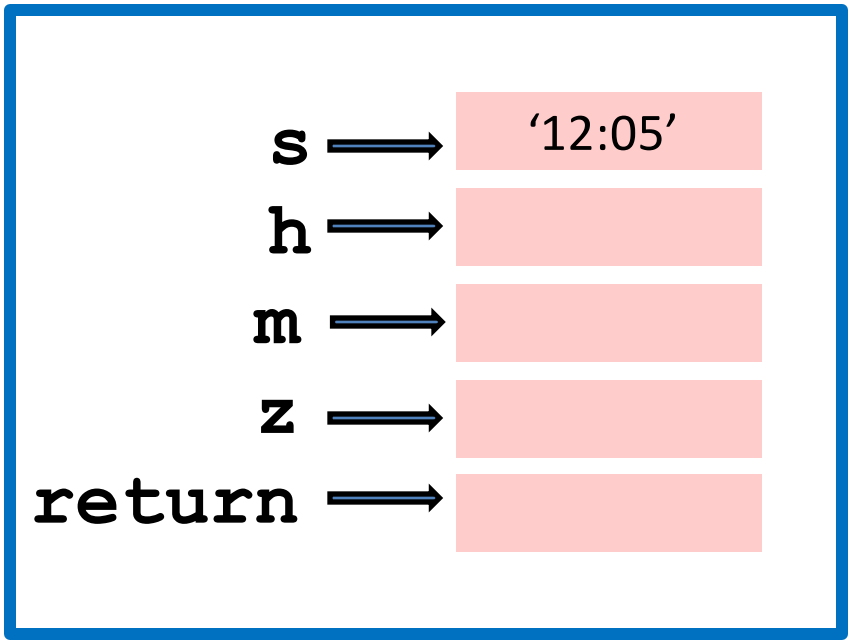


We open up the Call Frame

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

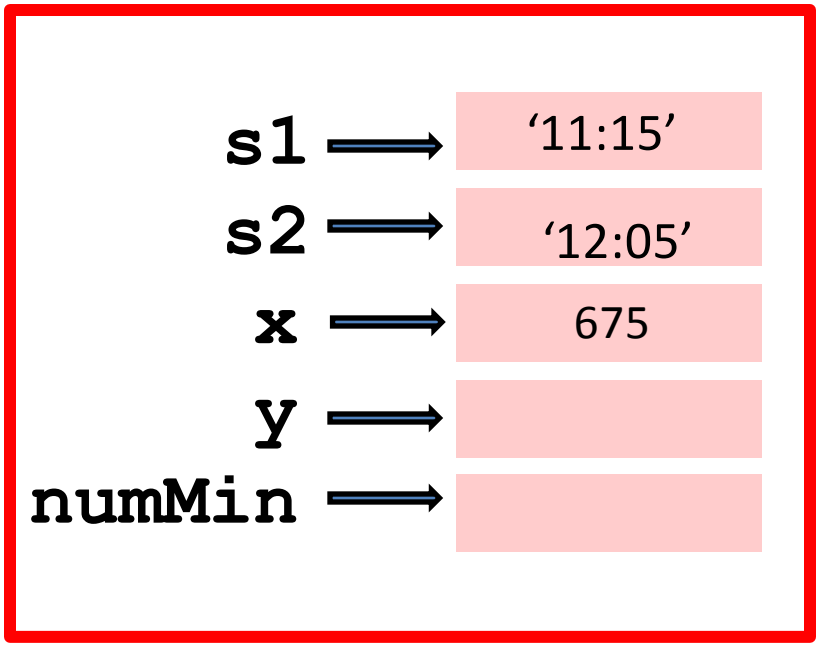


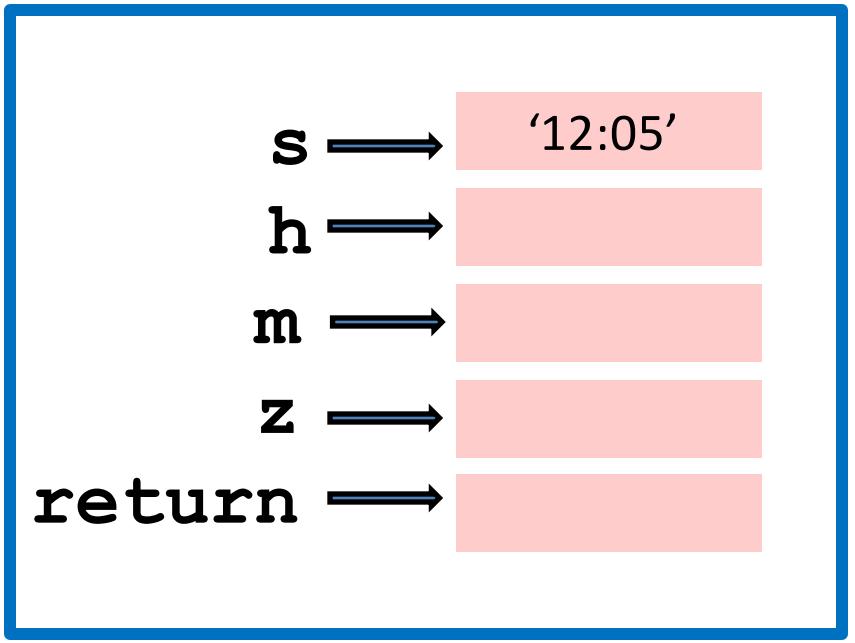


The value of the argument (housed in s2) is substituted

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

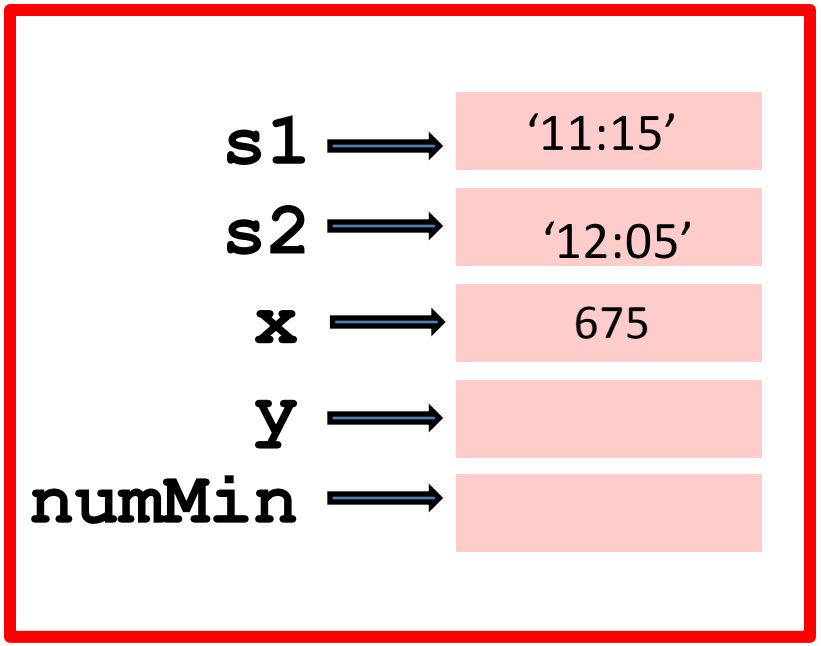


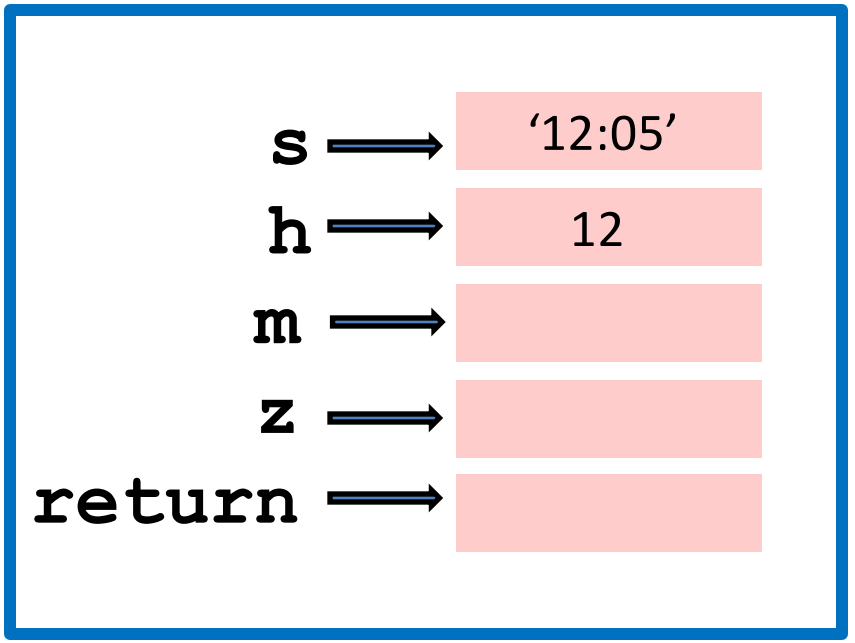


Execution of the function body starts.

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

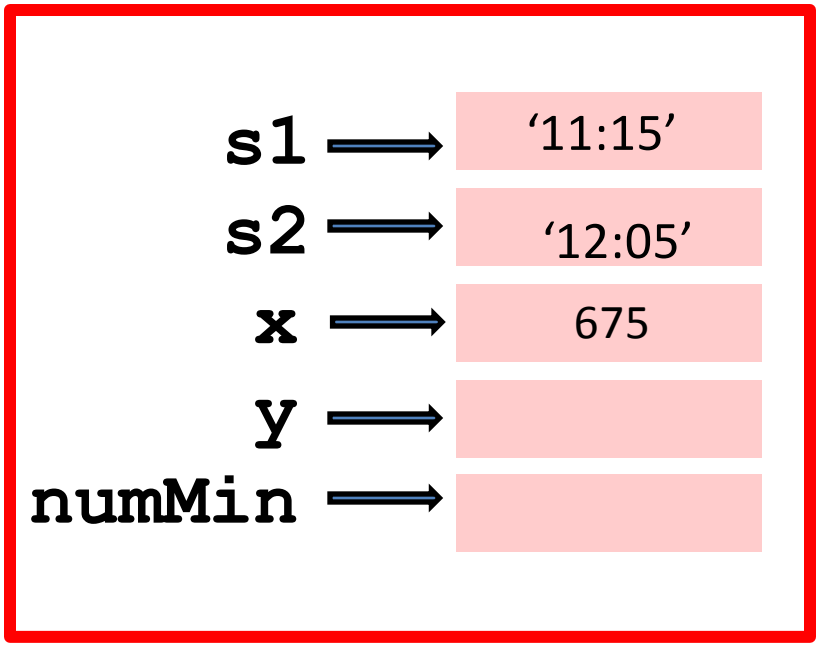


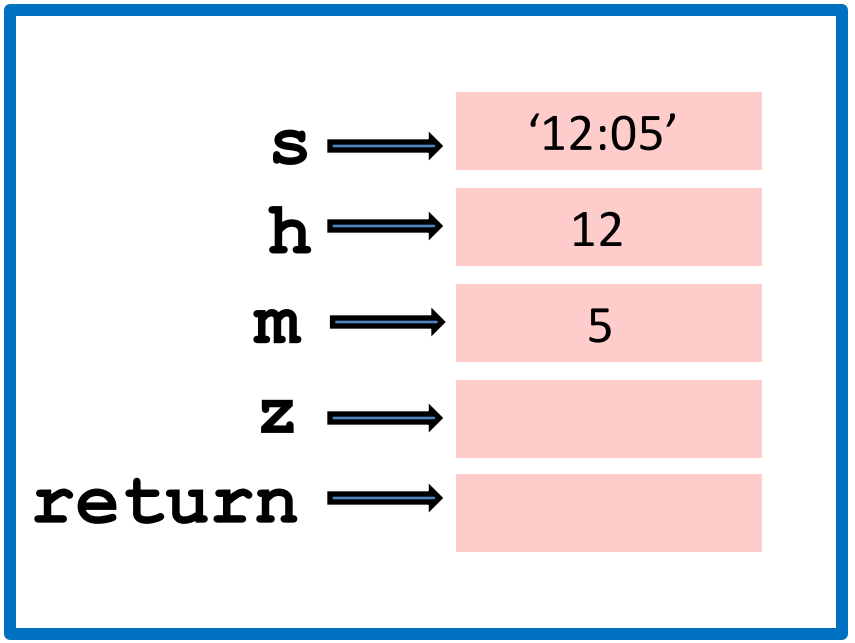


We step through the function body

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

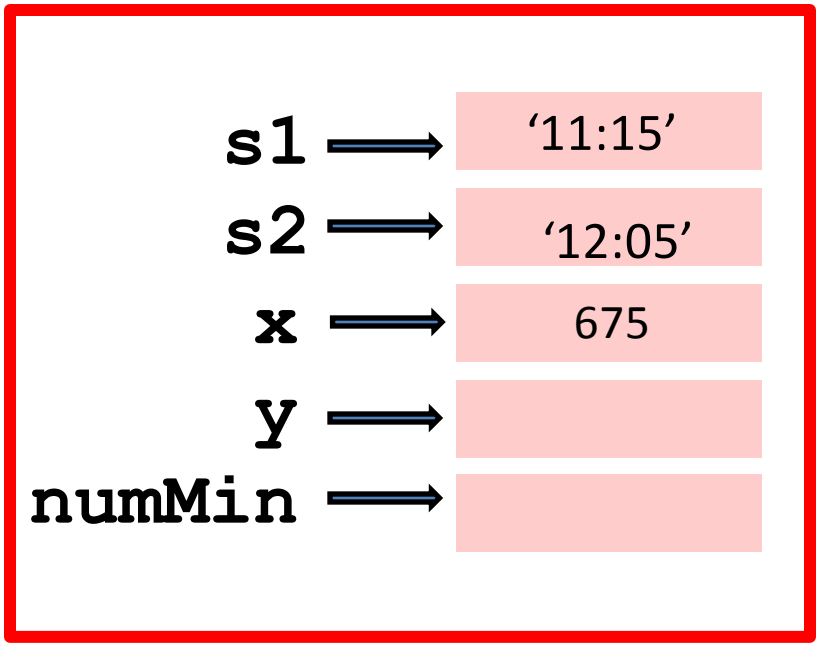


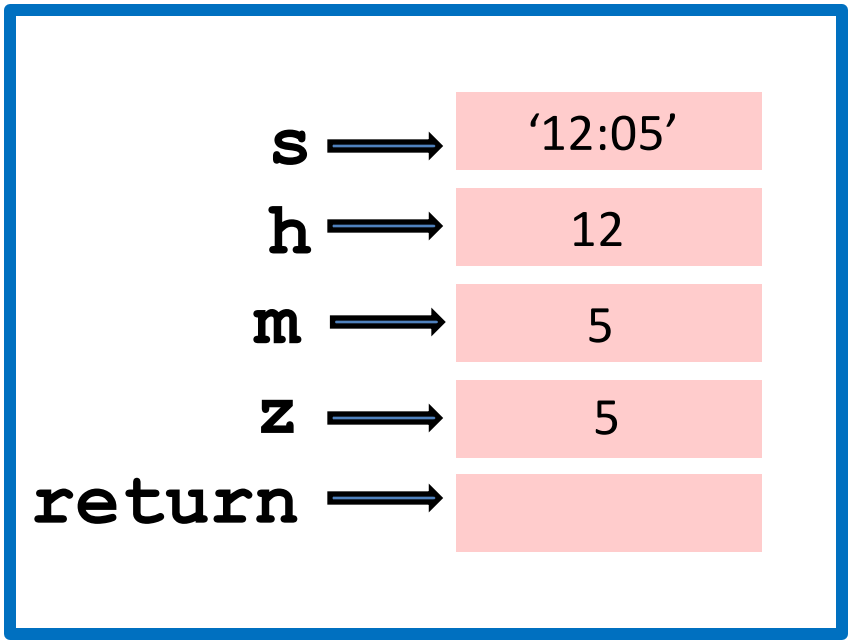


We step through the function body.

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```





We step through the function body.

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

s1	'11:15'
s2	'12:05'
x	675
y	
numMin	

s	'12:05'
h	12
m	5
z	5
return	5

The value in z is to be returned

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```

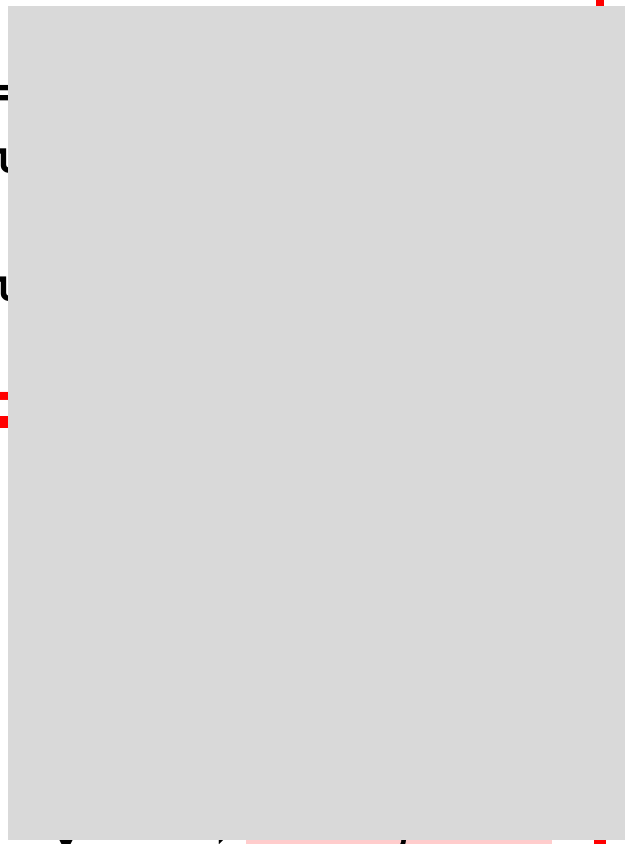
```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

s1	'11:15'
s2	'12:05'
x	675
y	5
numMin	

s	'12:05'
h	12
m	5
z	5
return	5

That value is sent back to the red dot.

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T
if y>=
    nu
else:
    nu
print
```



numMin ⟹ 50

s ⟹

h ⟹

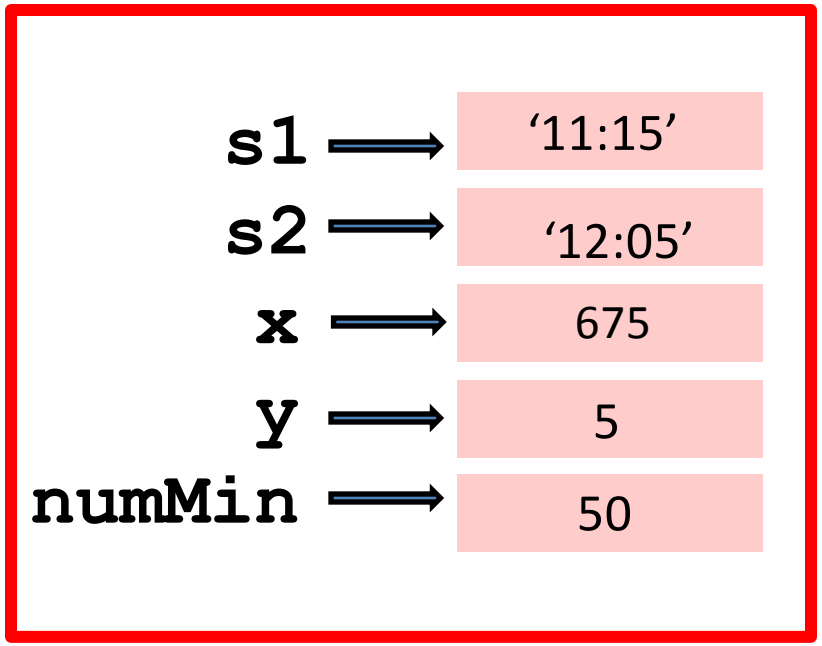
m ⟹

z ⟹

return ⟹

Function call is over. Call Frame disappears. Red dot moves on

```
s1 = '11:15'
s2 = '12:05'
x = T(s1)
y = T(s2)
if y>=x:
    numMin = y-x
else:
    numMin = (y+720)-x
print numMin
```



50

The script is over. Global space disappears.

50

The script is over. Global space disappears.