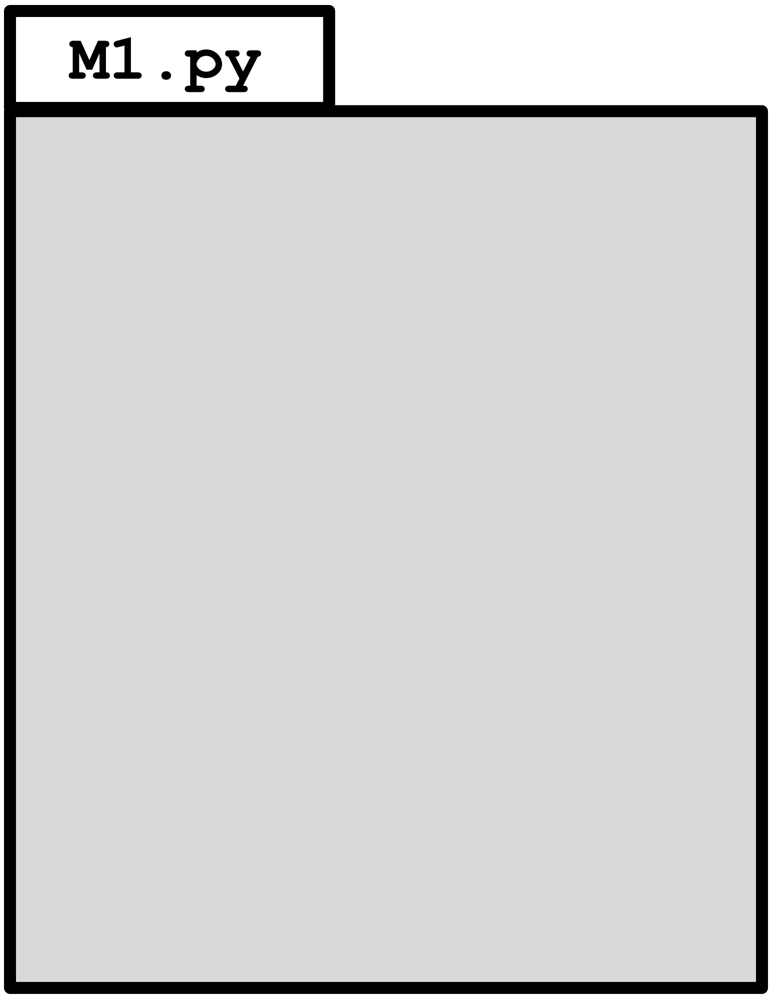
6. How Modules and Functions Work

Topics:

- Modules and Functions
- More on Importing
- Call Frames

Let's Talk About Modules

What Are They?

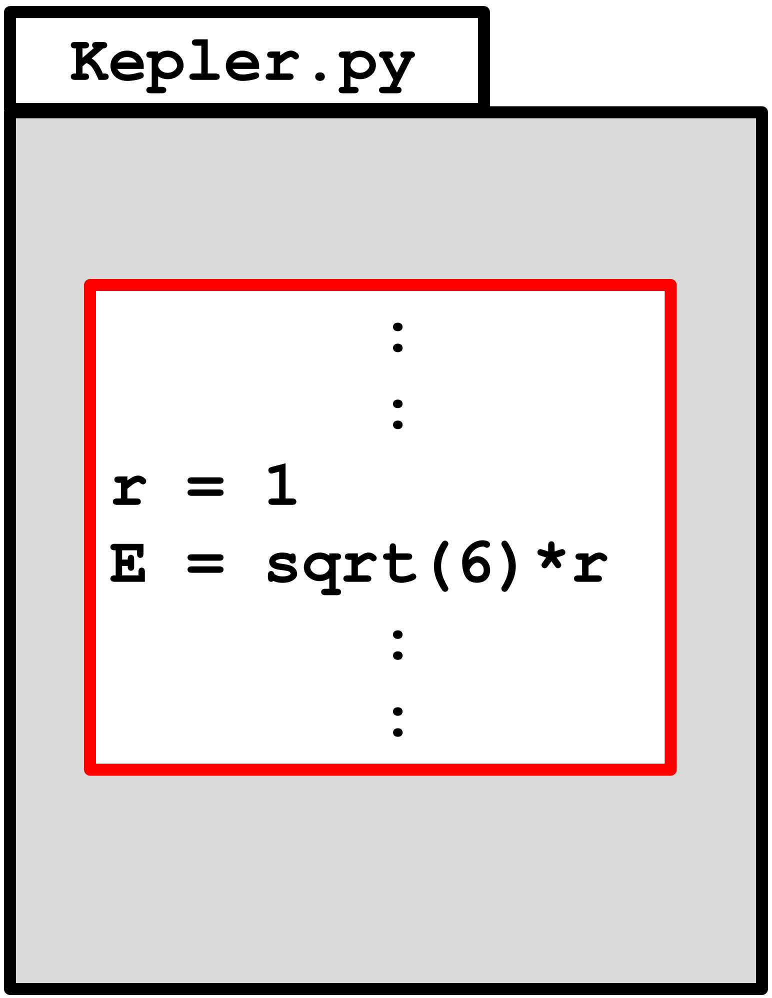


A module is a .py file that contains Python code

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.

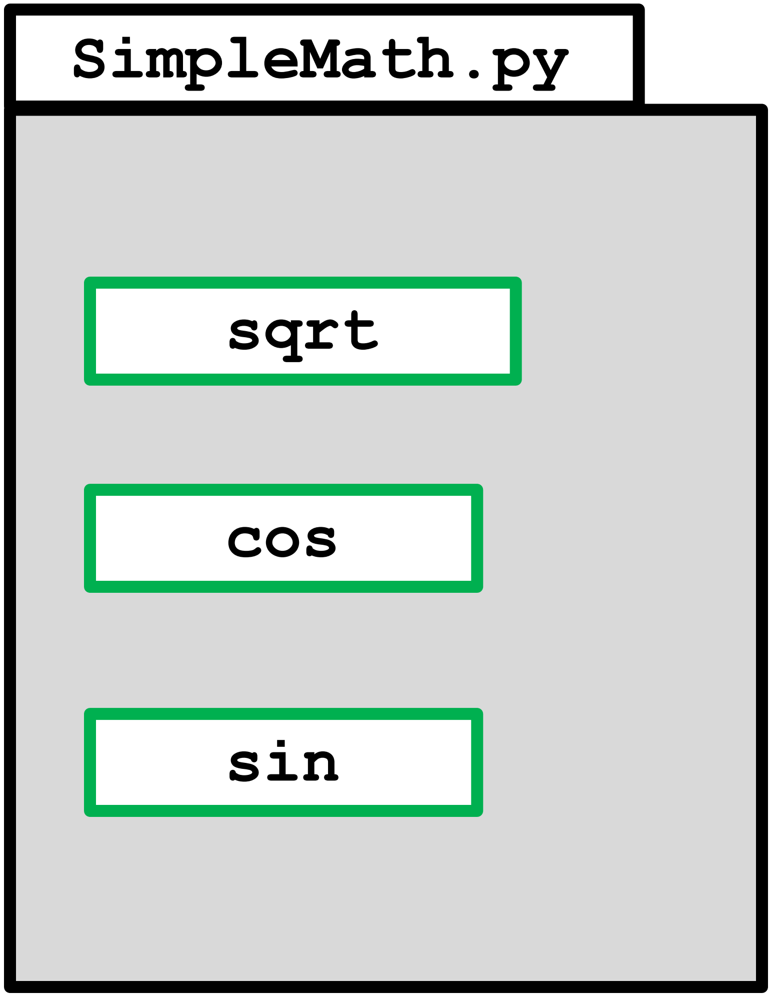
Inside a Module



A module may contain a single script.

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

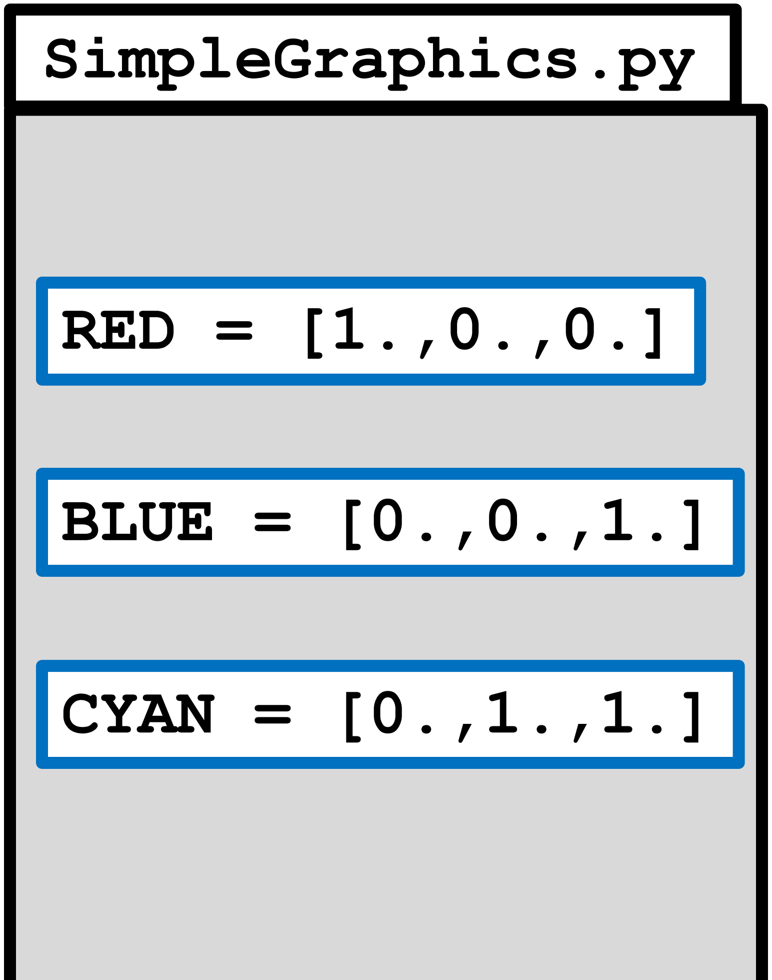
Inside a Module



A module may contain one or more function definitions.

Functions will be shown as rectangles with green borders.

Inside a Module

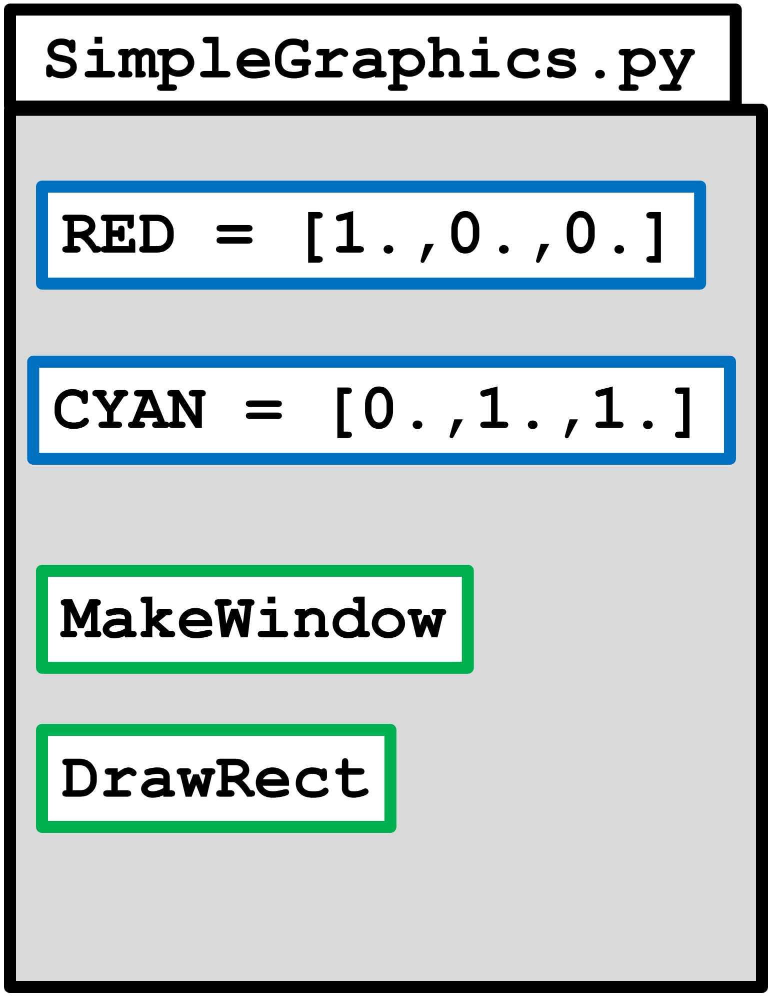


A module may contain one or more data items.

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

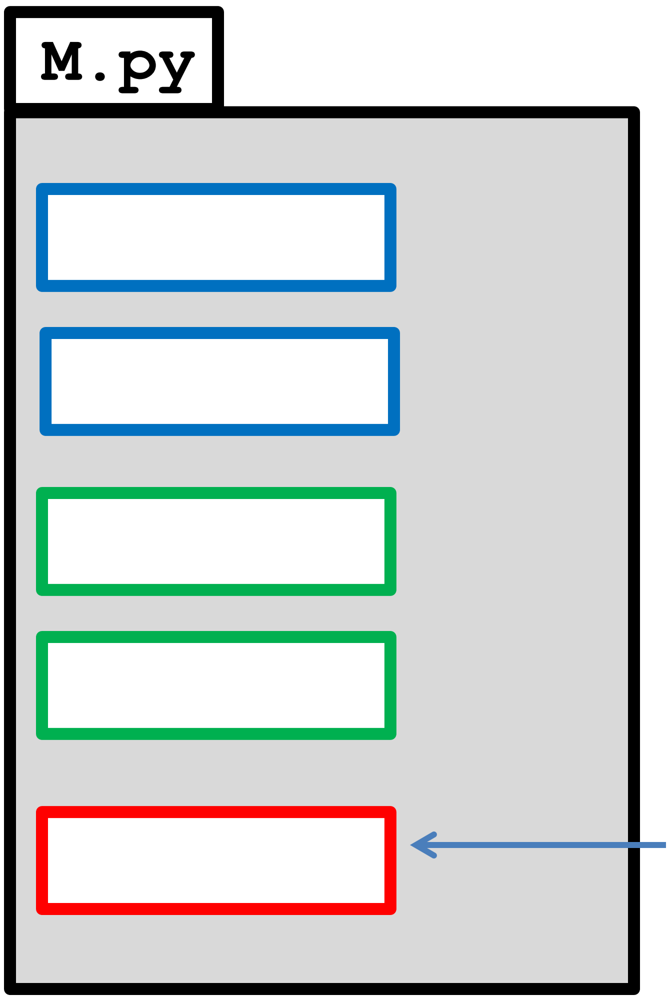
Data items will be shown as rectangles with blue borders.

Inside a Module



A module may contain one or more data items <u>and</u> one or more functions.

Inside a Module



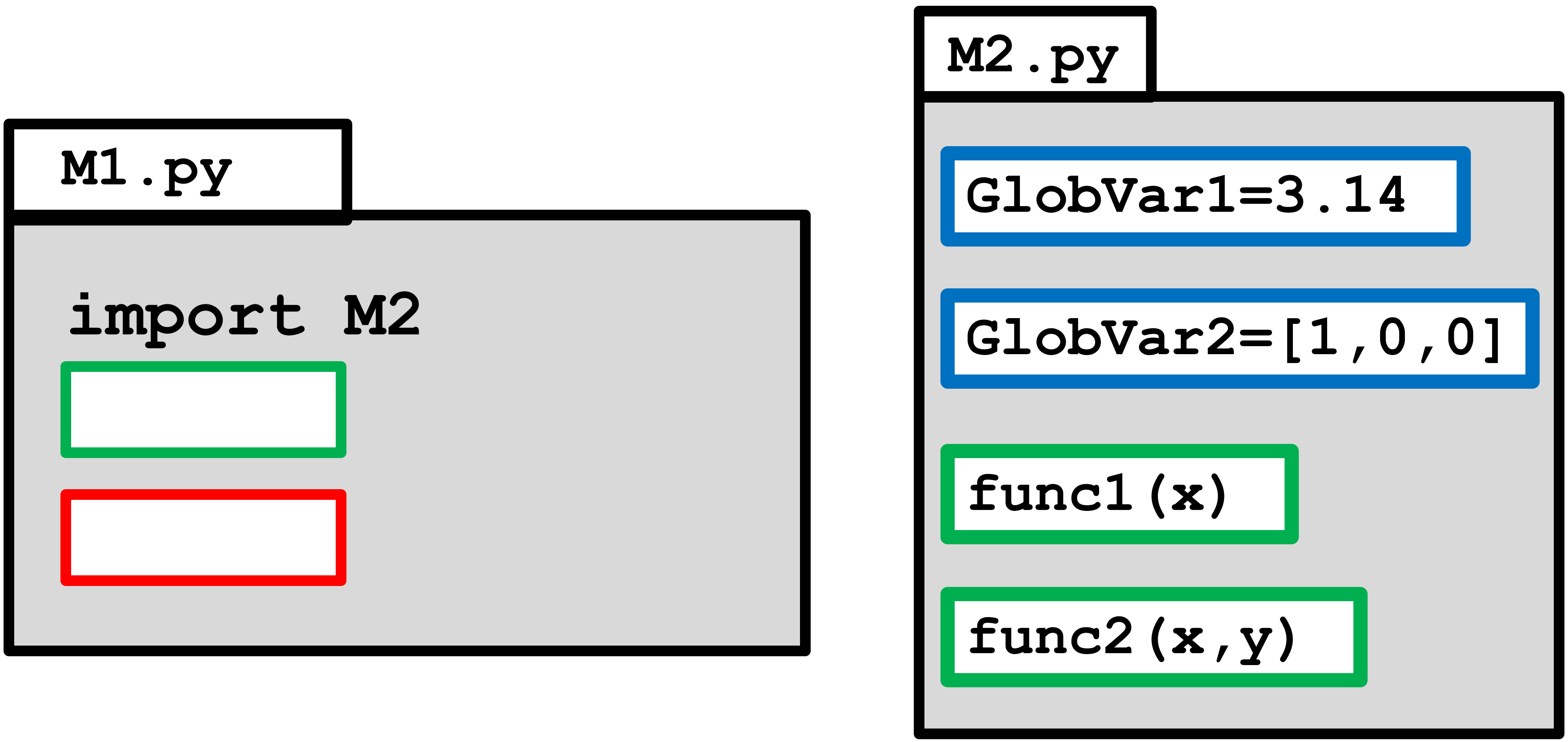
A module may contain
one or more data items
and one or more functions
and a script.

But in this case, the script
MUST be prefaced by

```
if __name__ == ‘__main__’:
```

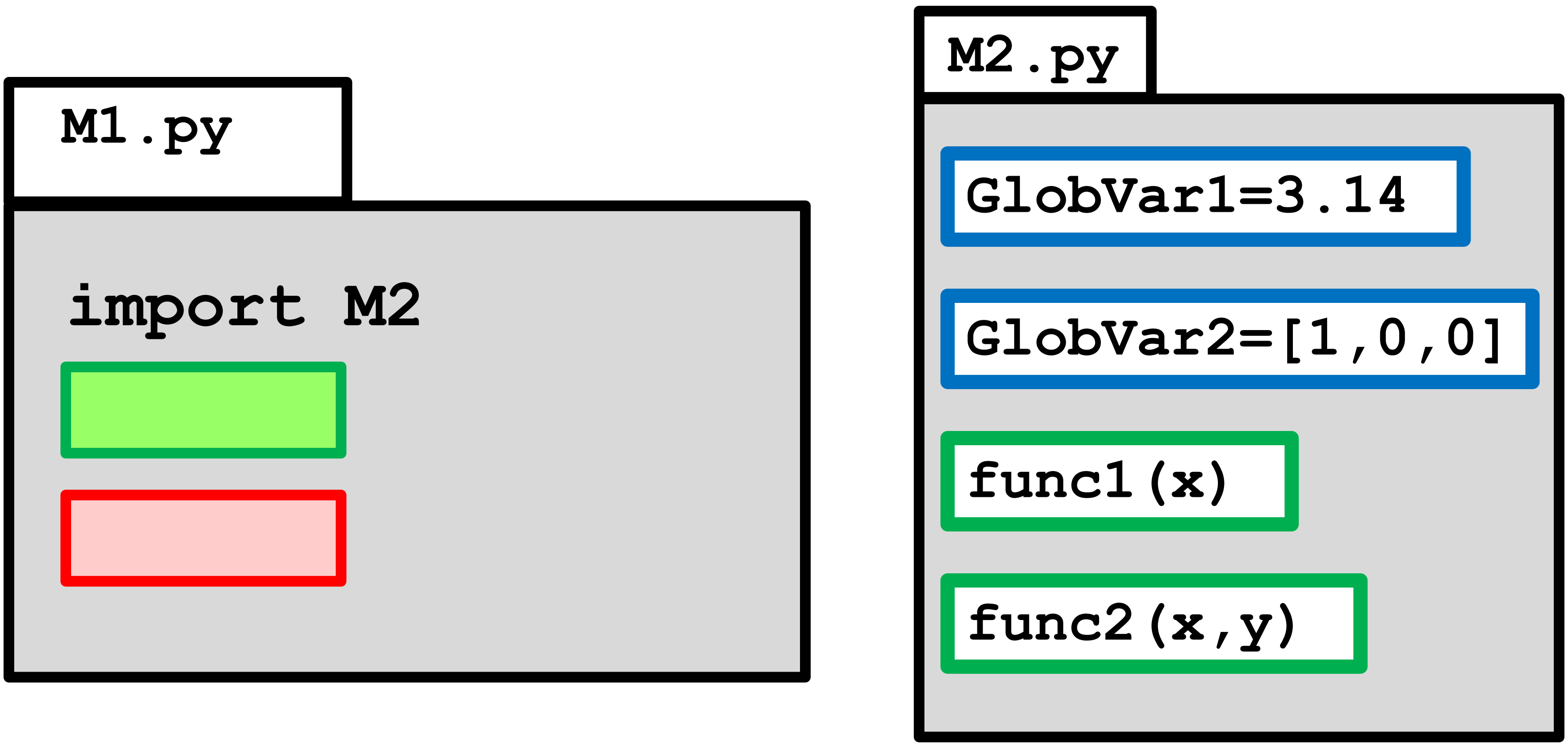
Let's Talk About `import`

What Does import Allow?



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

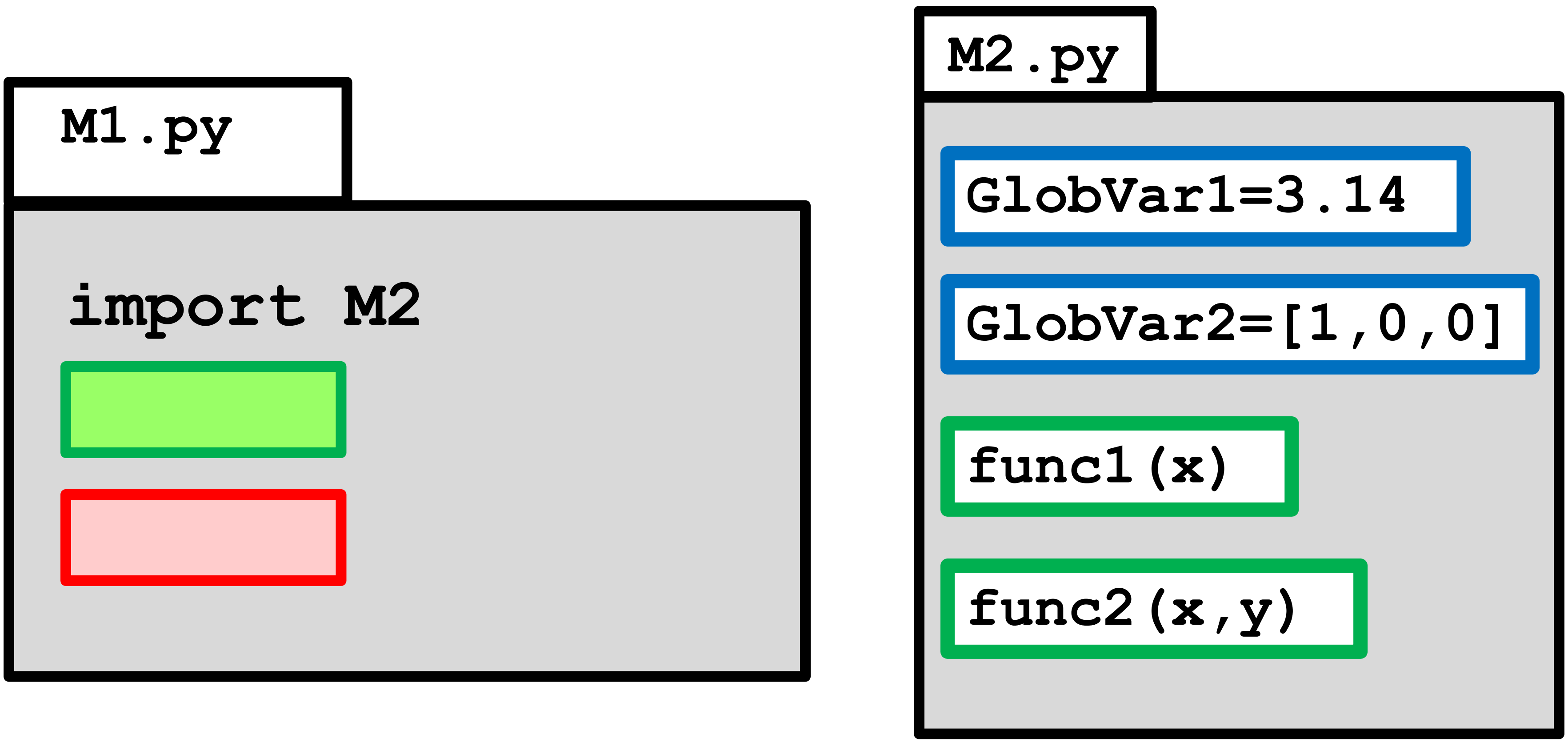
What Does import Allow?



A function [green box] in `M1.py` could have a line like

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

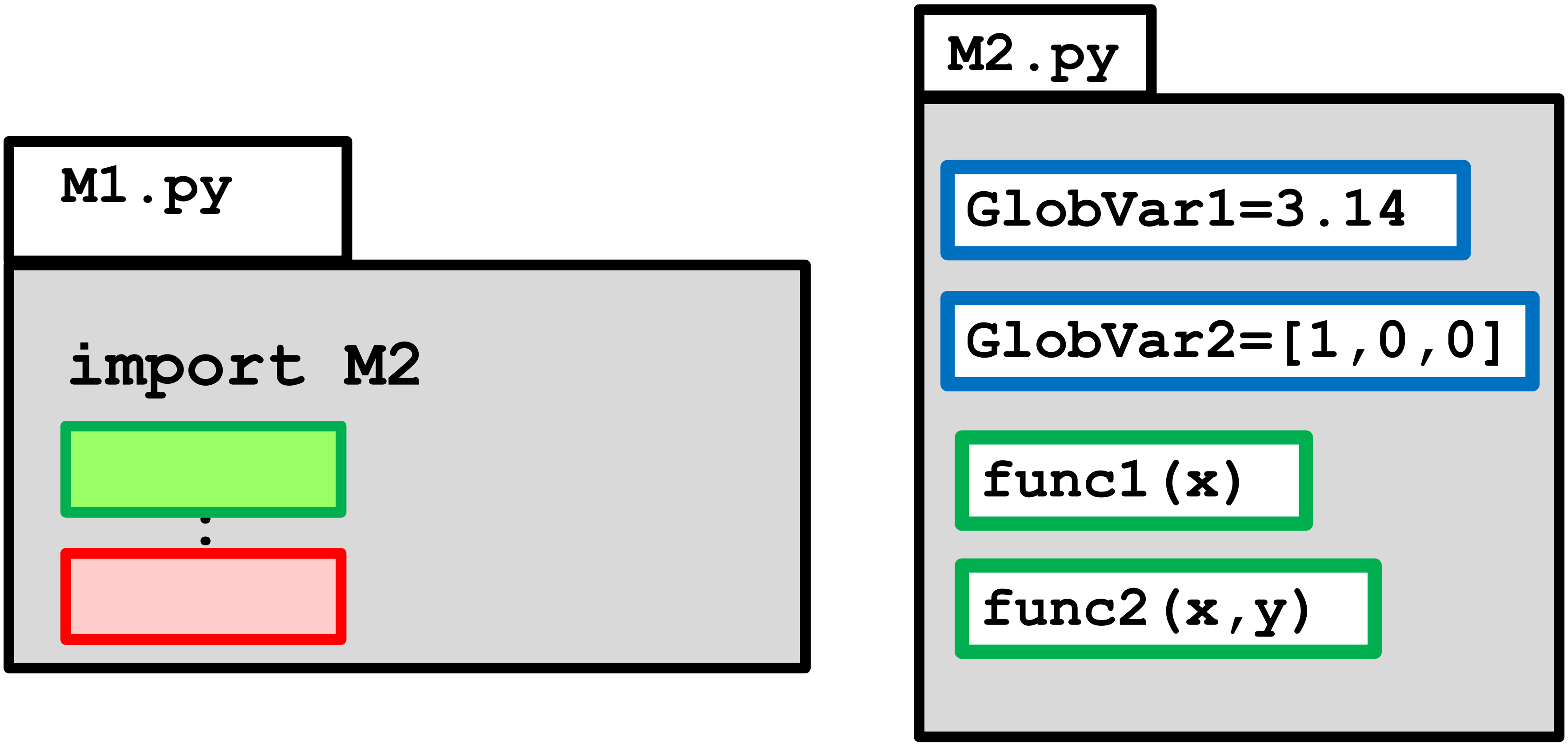
What Does import Allow?



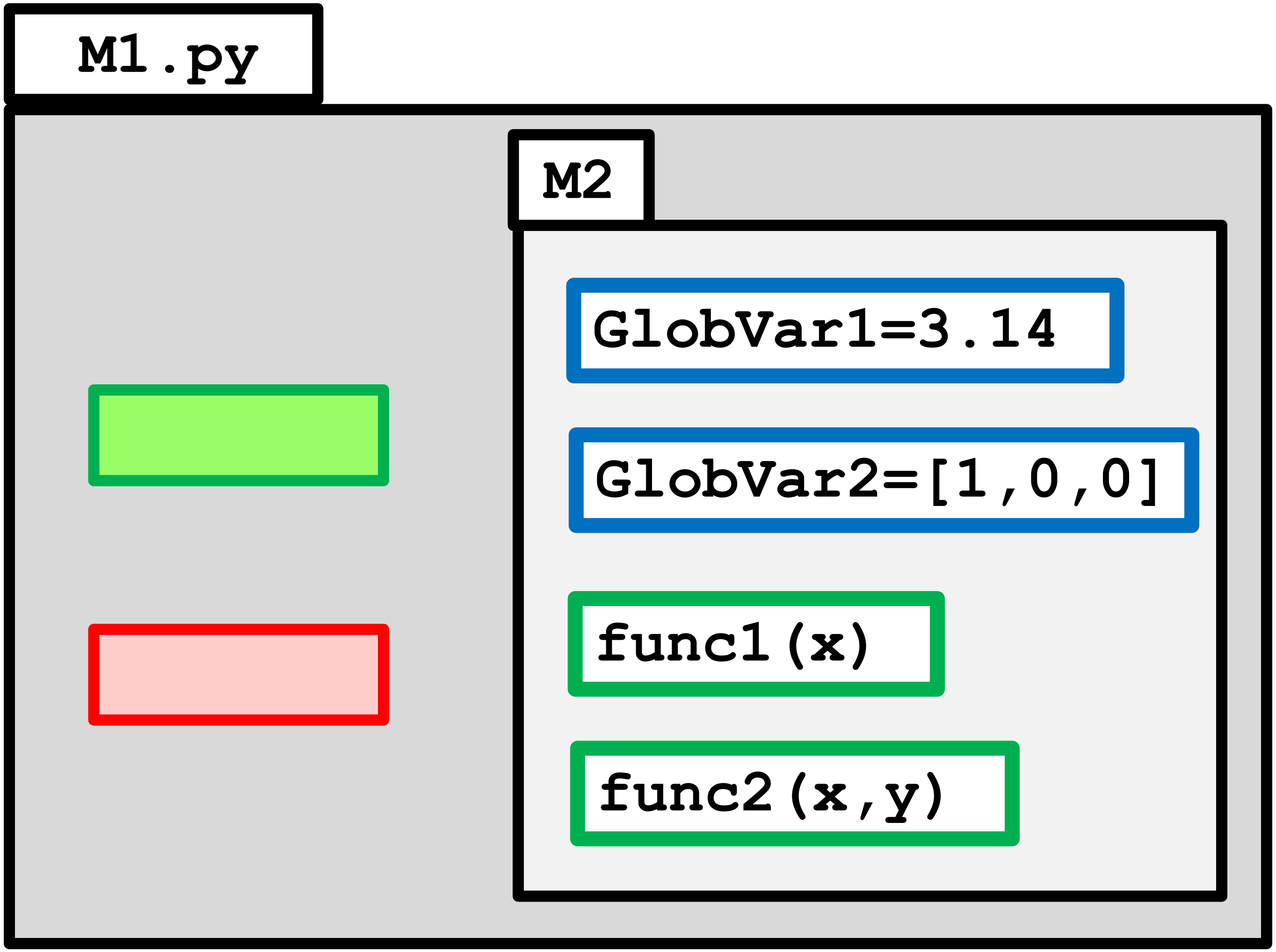
The script [red box] in **M1.py** could have a line like

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

One Way to Think About this...

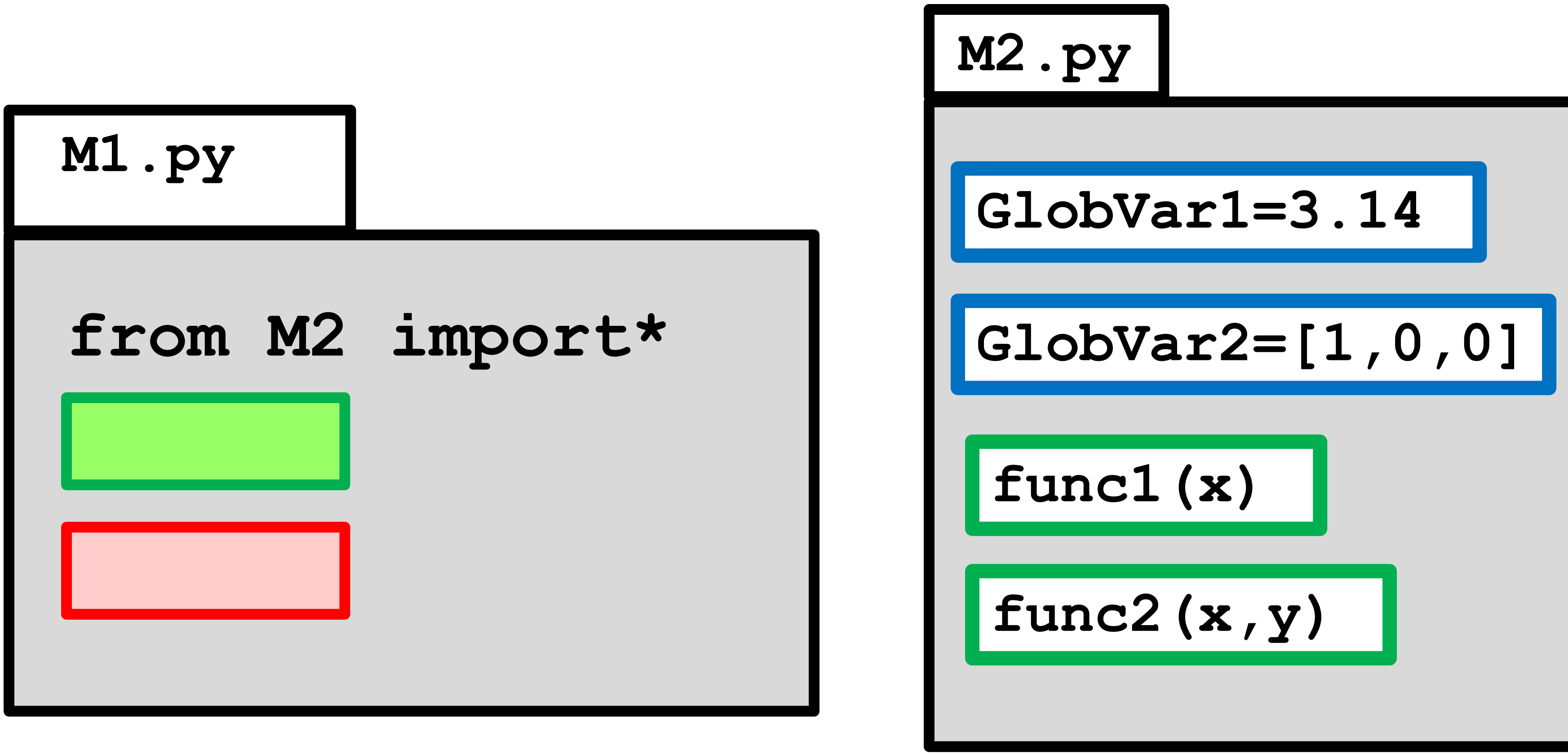


is like this...



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

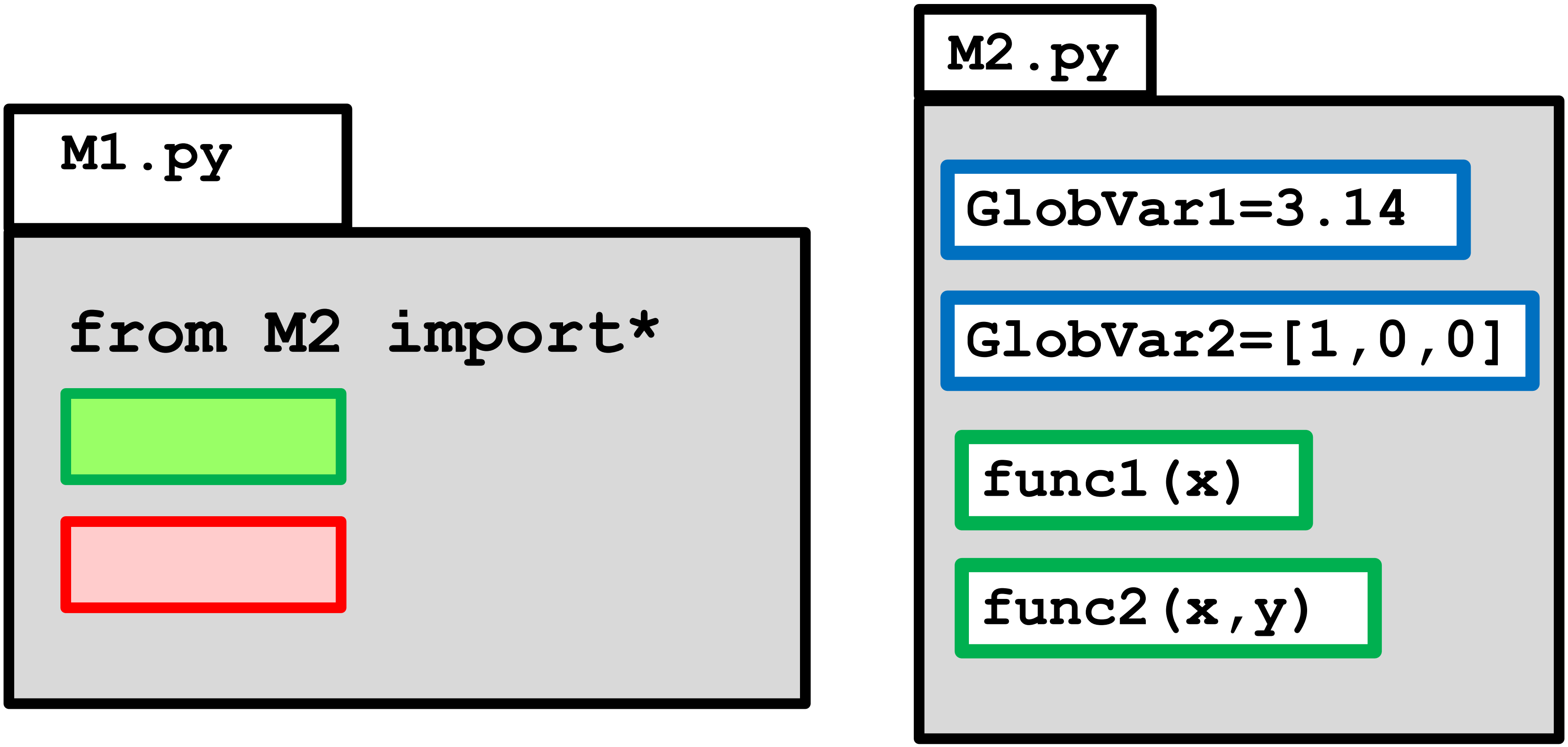
What Does `import*` Allow?



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

No dot notation

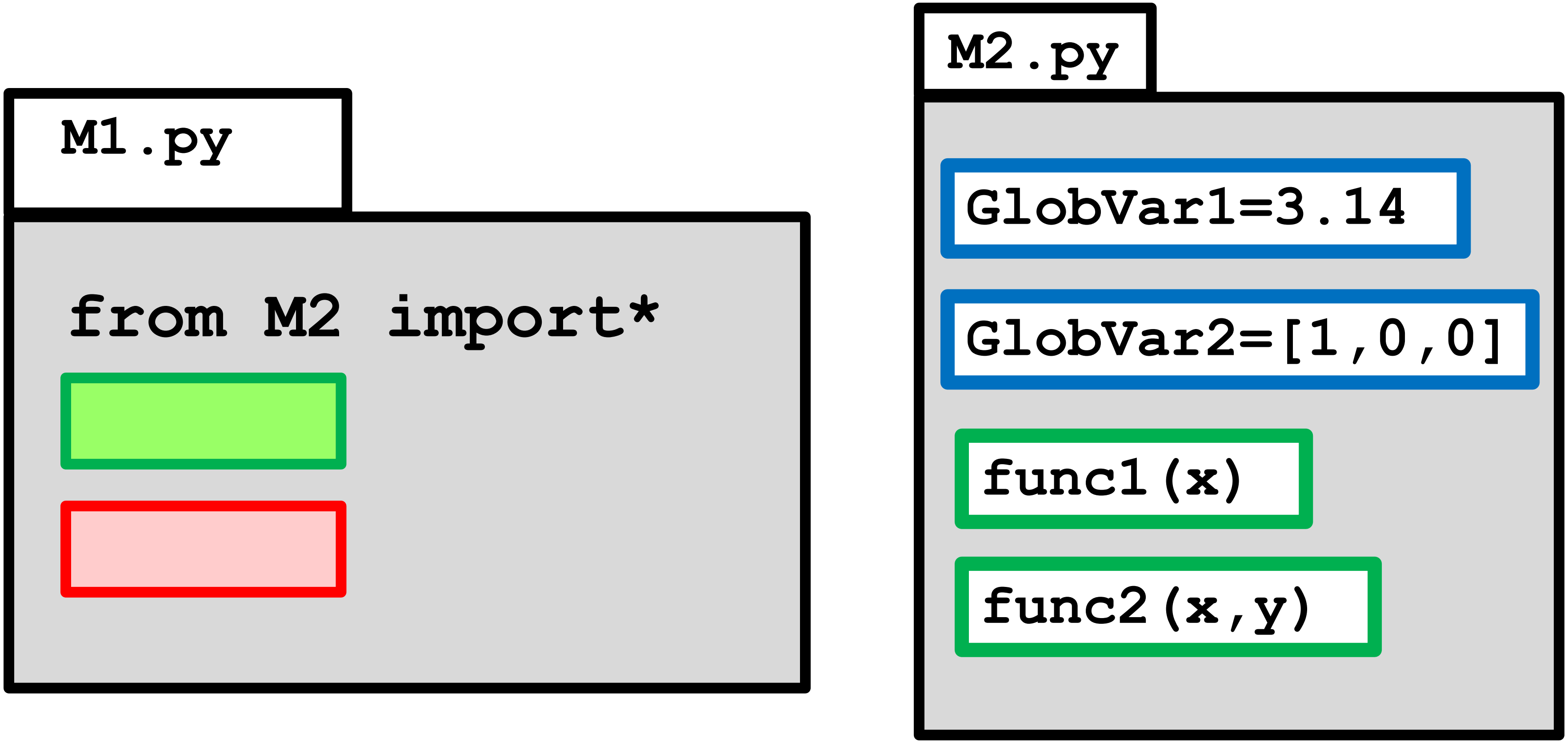
What Does import* Allow?



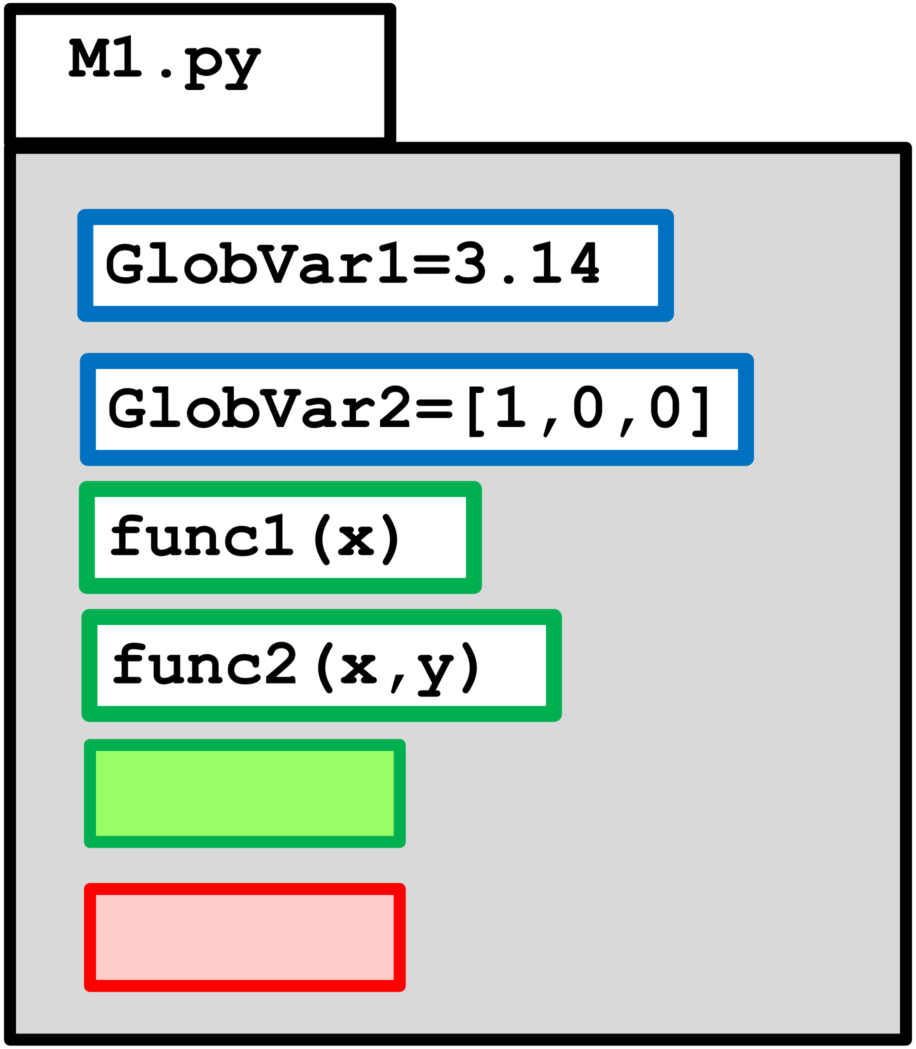
A script [red box] in M1.py could have a line like `a = func2(x,GlobalVar2)`

No dot notation

One way to Think about this…

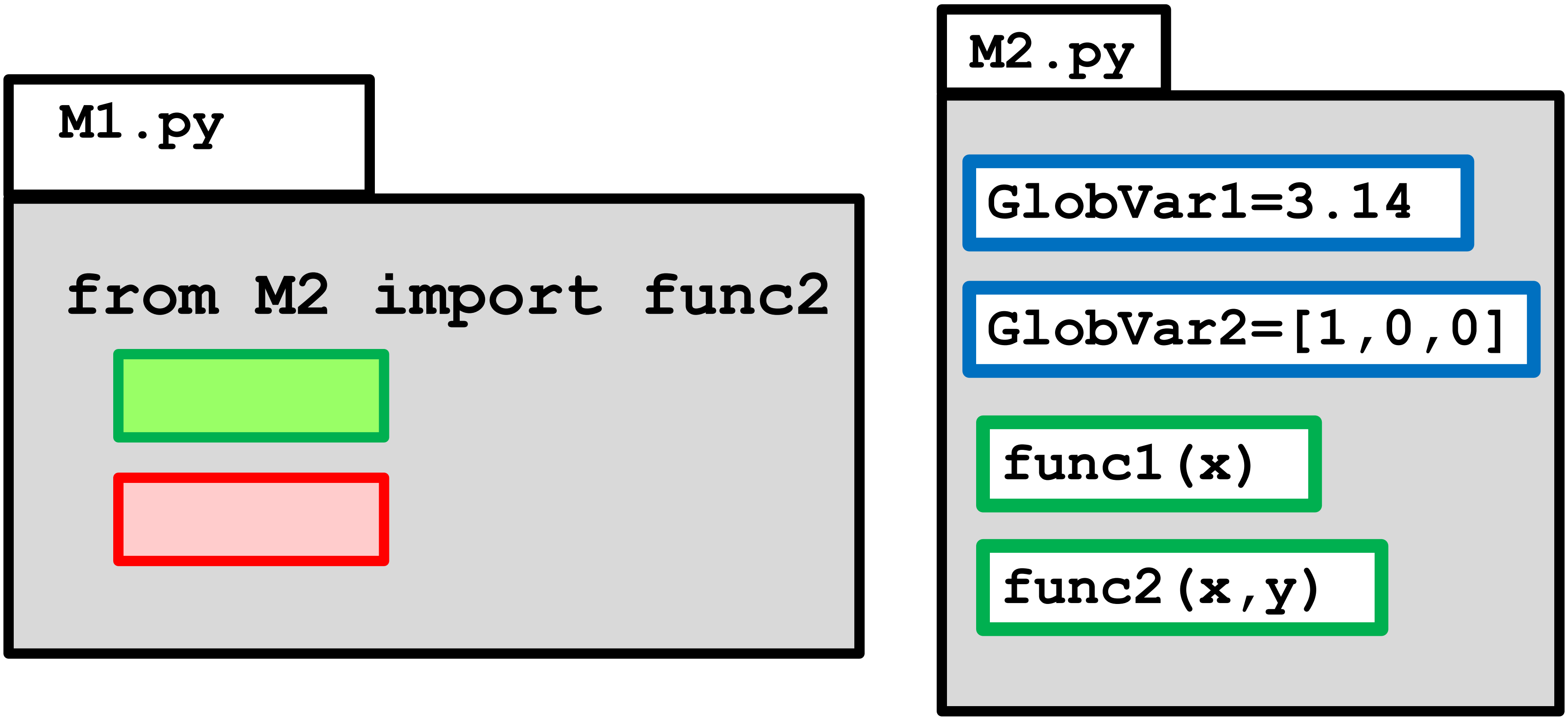


is like this…



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

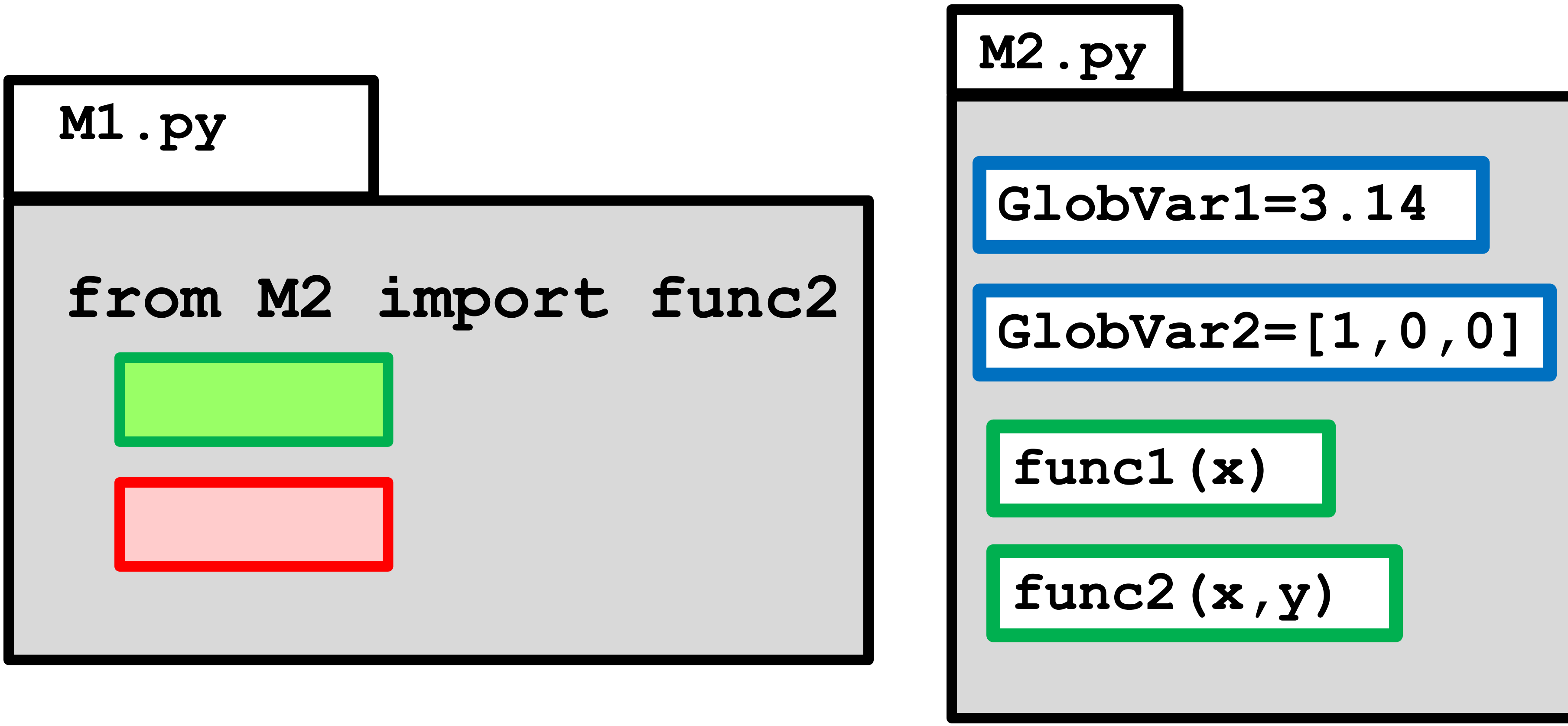
"Specific" Importing



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

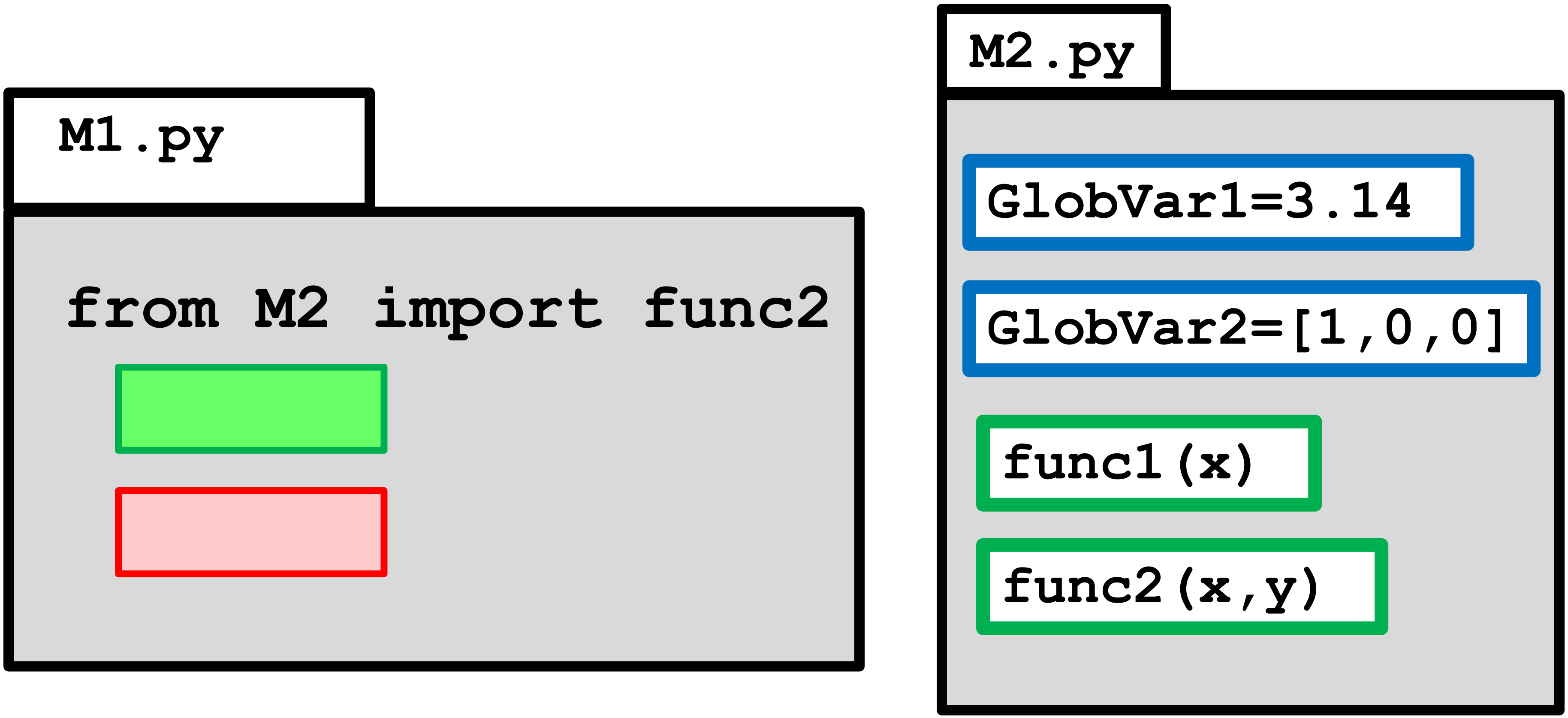
No dot notation

"Specific" Importing

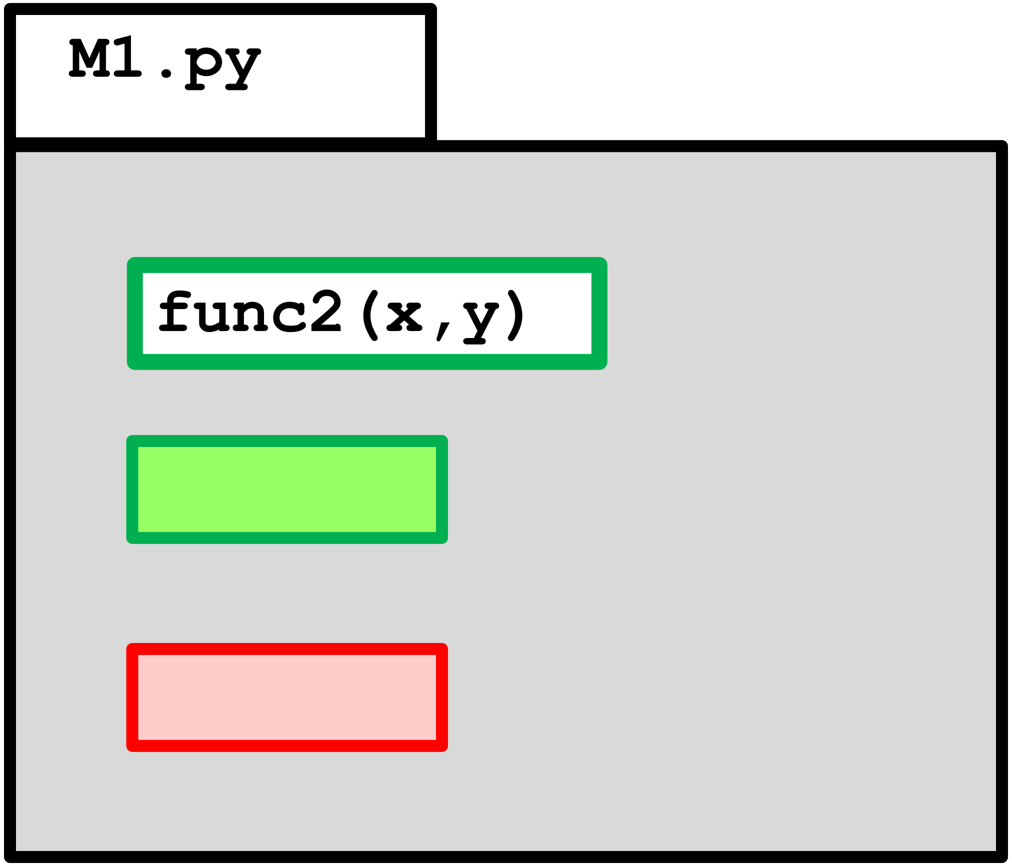


A script in `M1.py` could NOT have a line like `a = func1(4)`

One way to think about this…

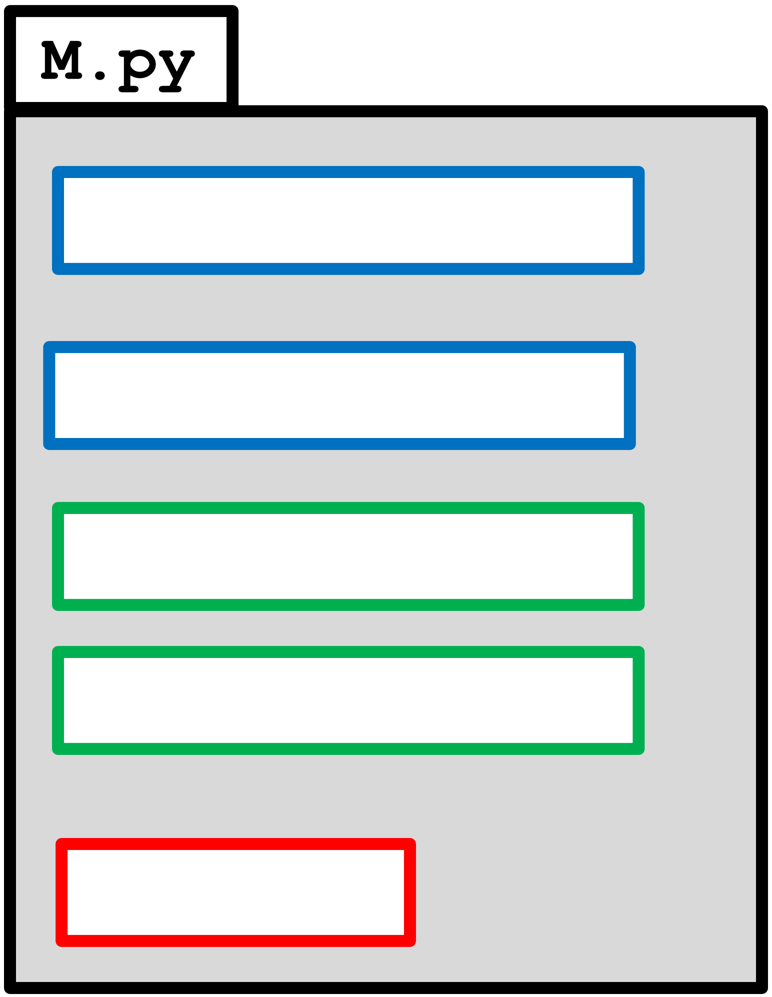


is like this…



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?

M1.py

```
import M2
    :
```

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?

M1.py

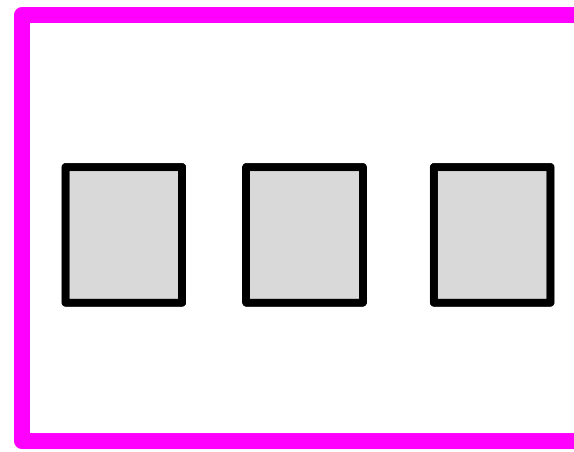
```
import M2
     :
```

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

.

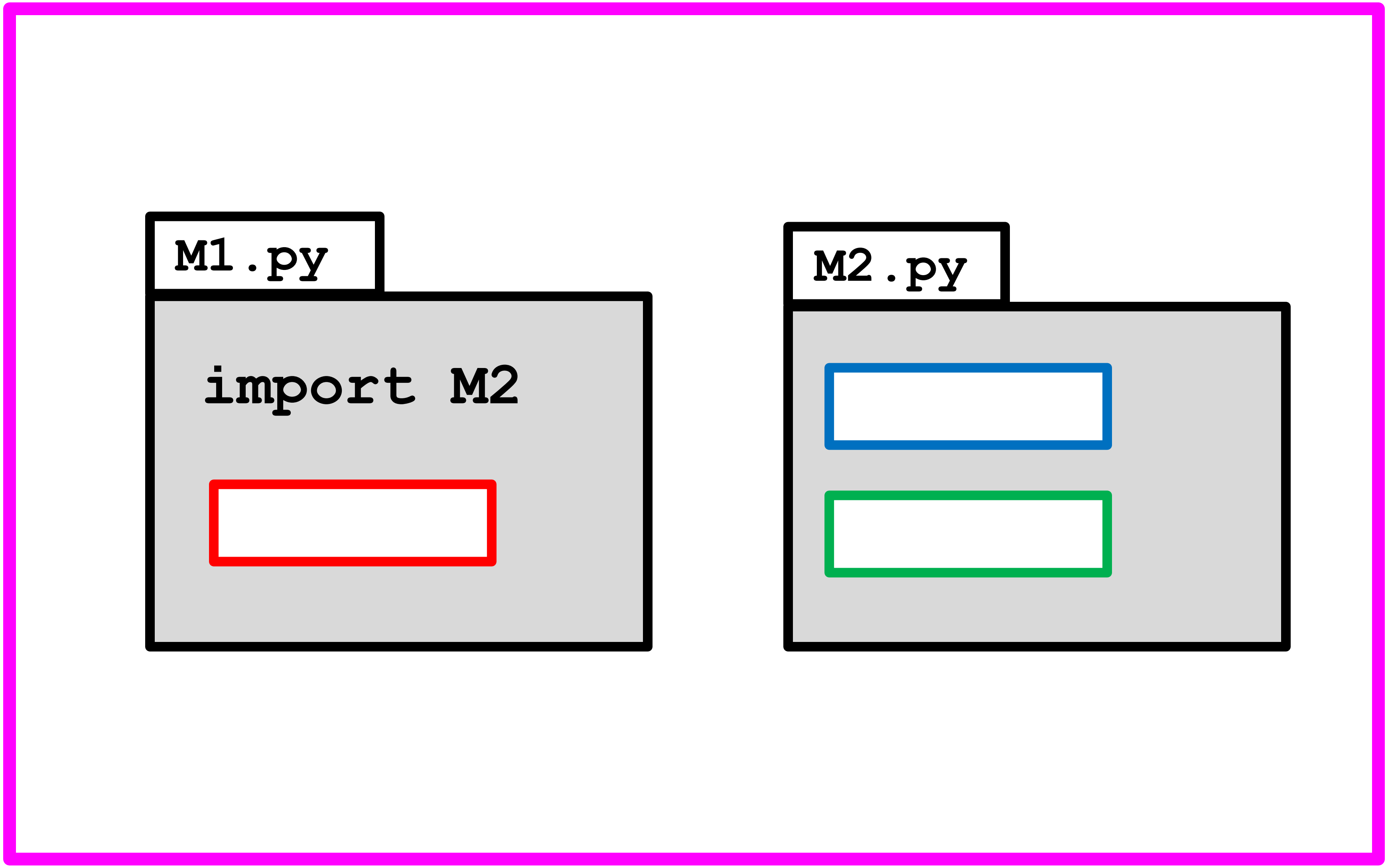
Comments on “Launching” a Python Computation

In what follows, this will be how we indicate what’s in the “current working directory” ➡



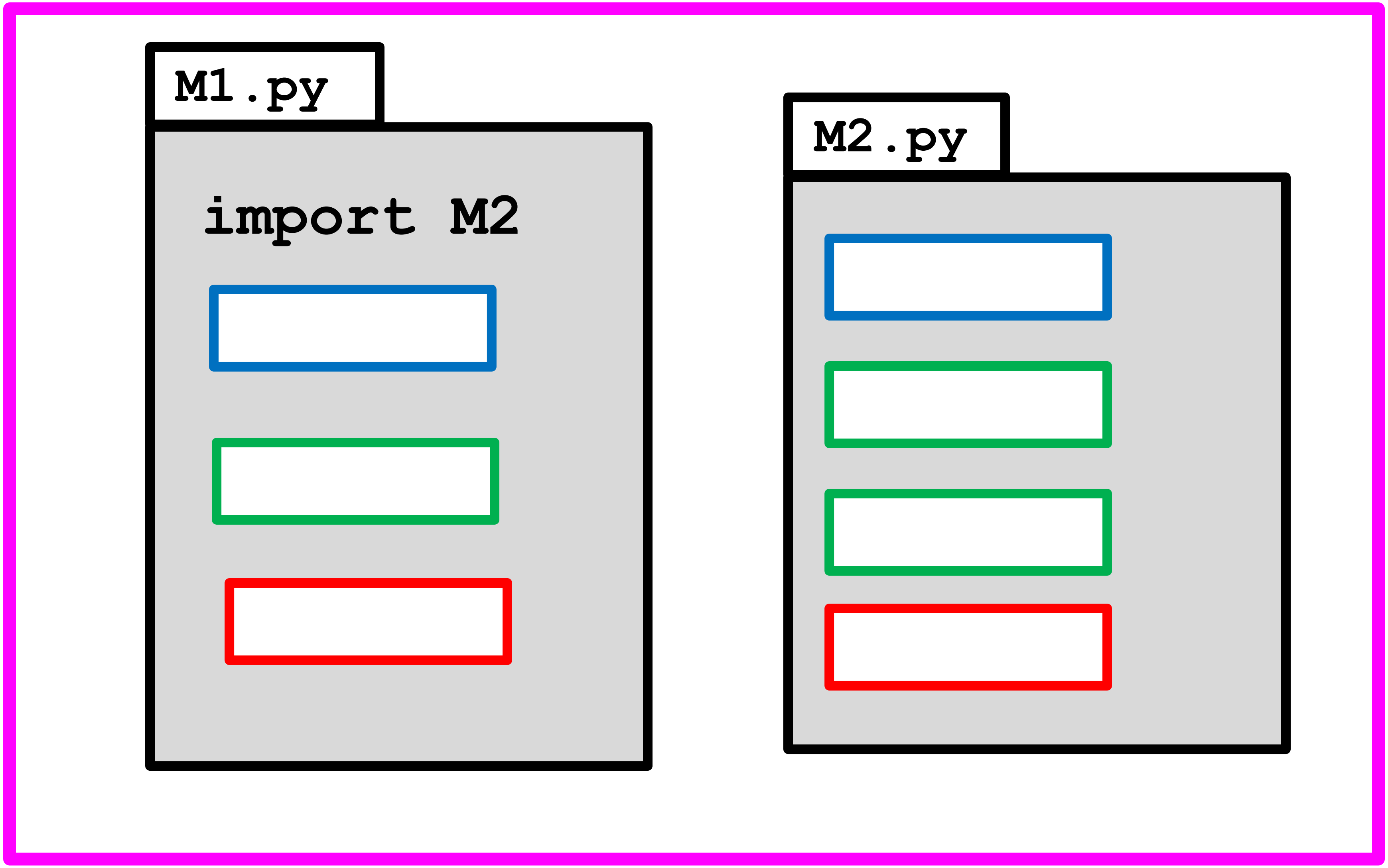
And this will mean we are in the command shell and in the “current working directory” ➡

`cwd >`



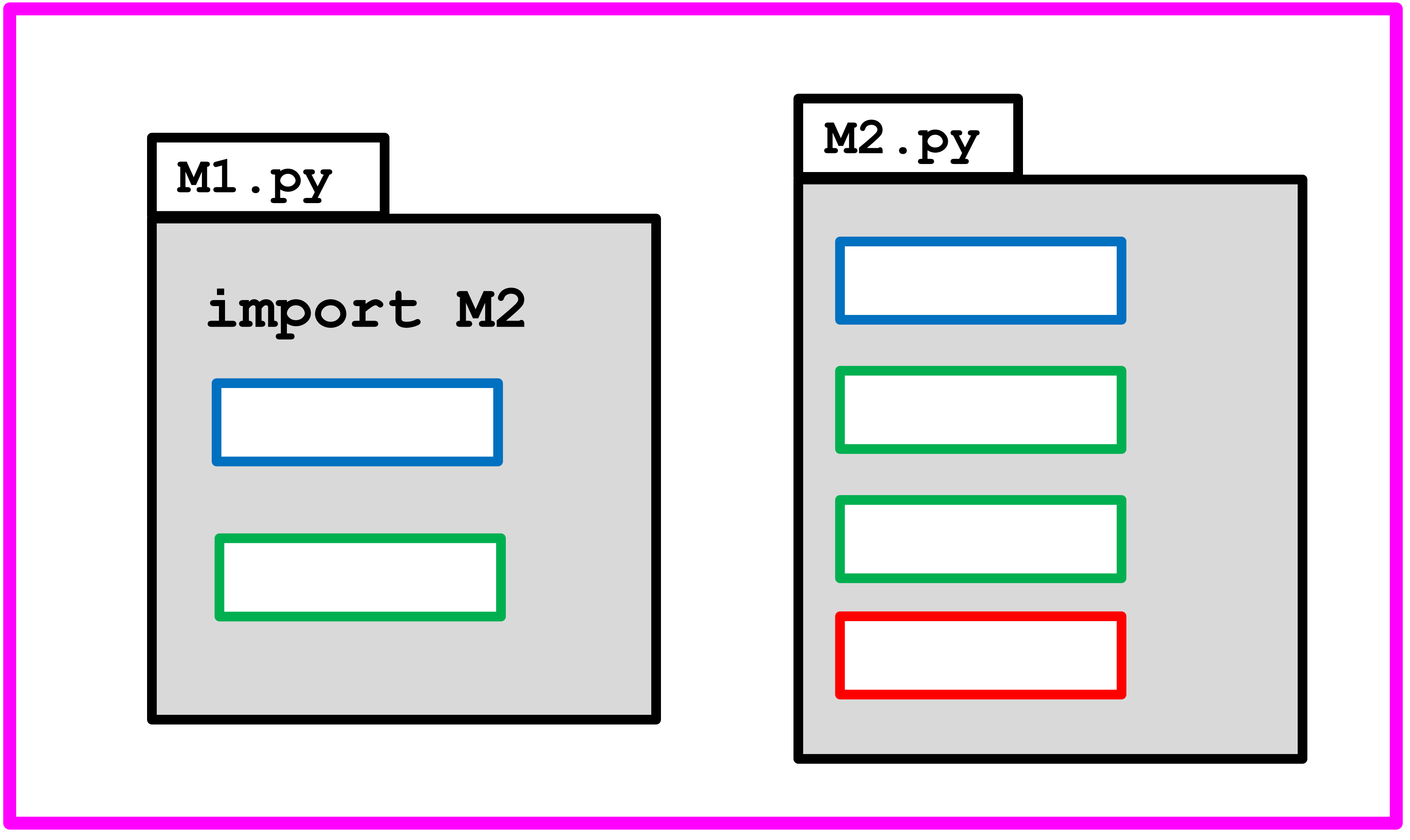
`cwd > python M1.py`

Result: the script in **M1.py** is executed.



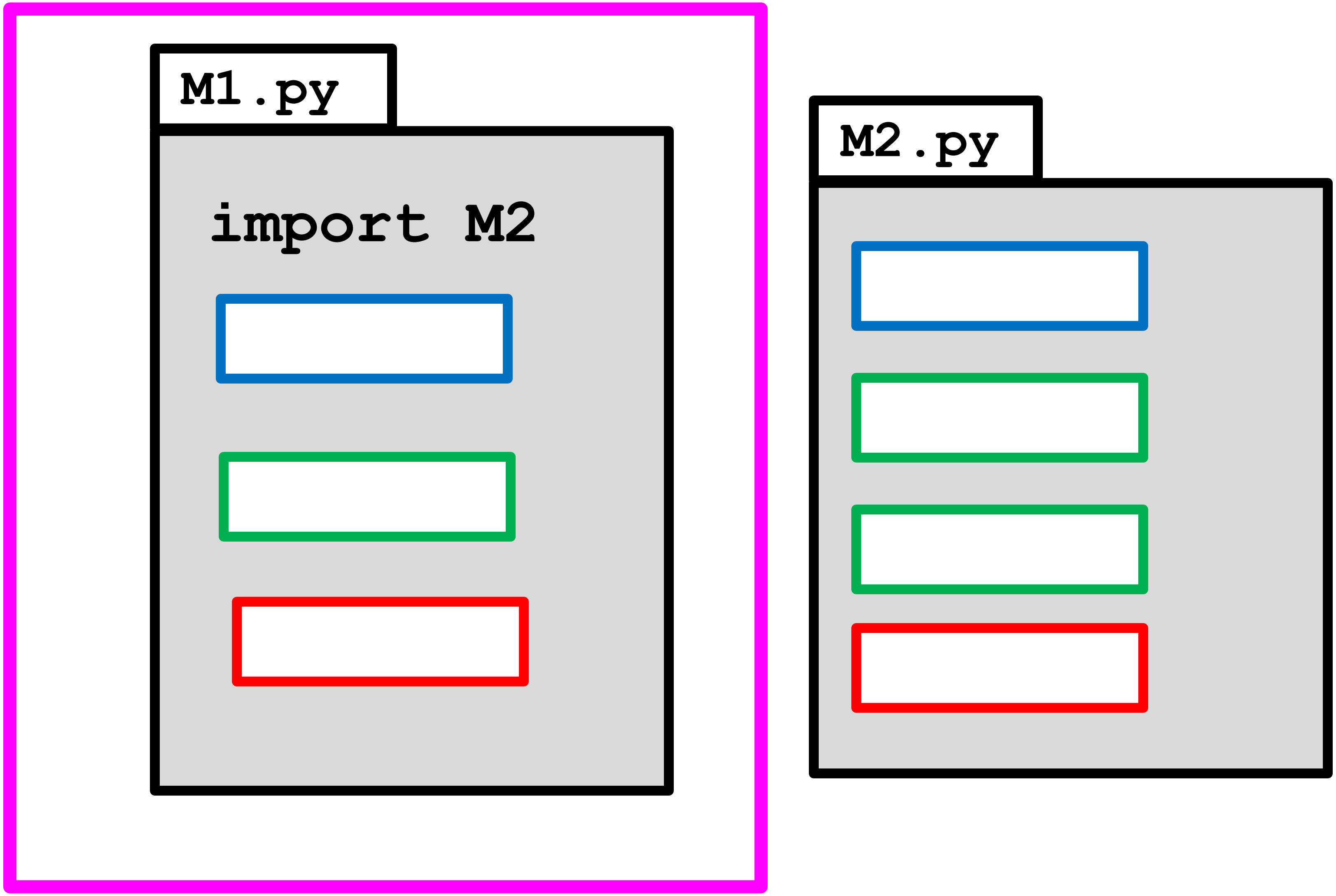

```
cwd > python M1.py
```

Result: the script in **M1.py** is executed. The script in **M2.py** is not executed



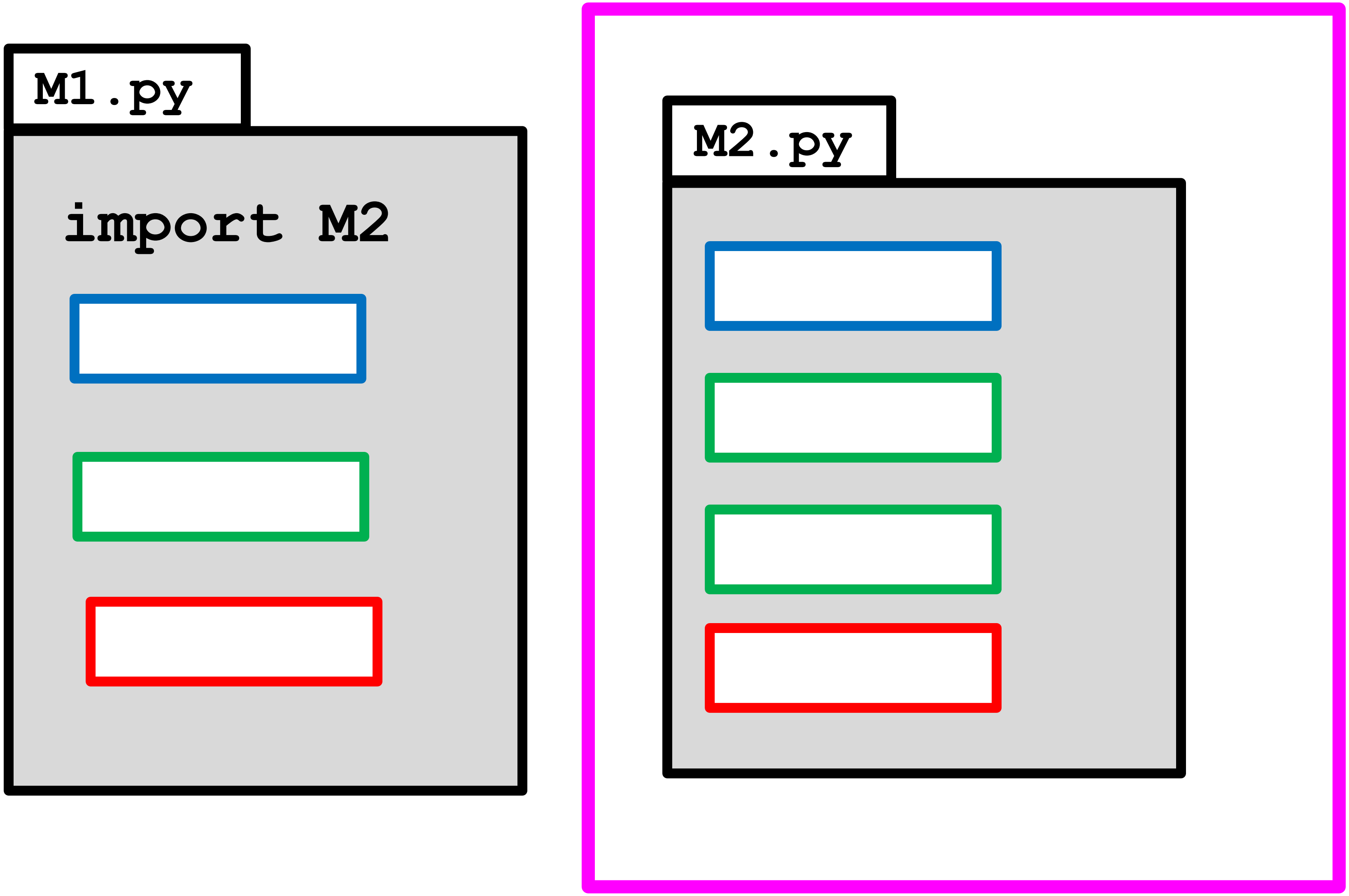
`cwd > python M1.py`

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



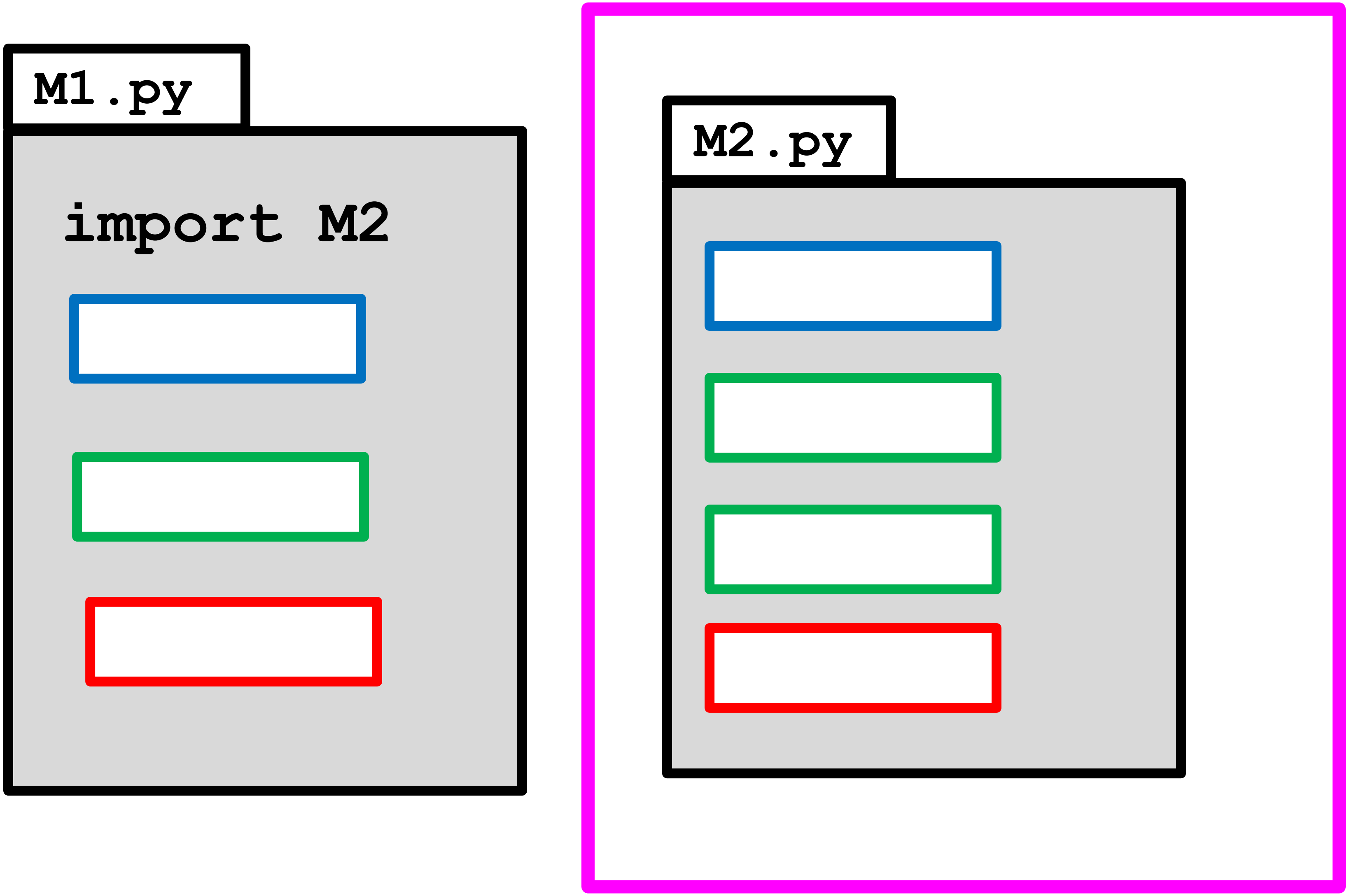

```
cwd > python M1.py
```

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`

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.

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**.

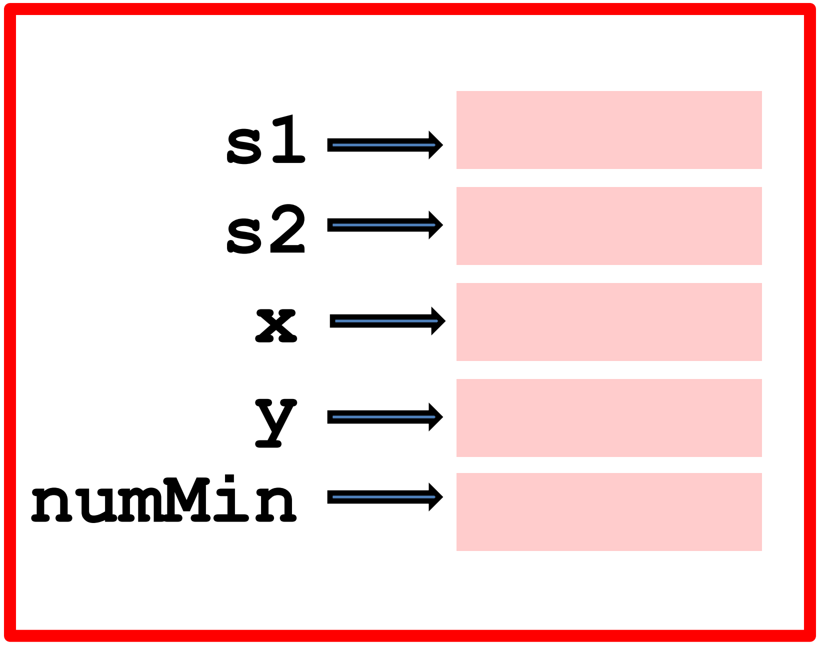
A Script

```
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.

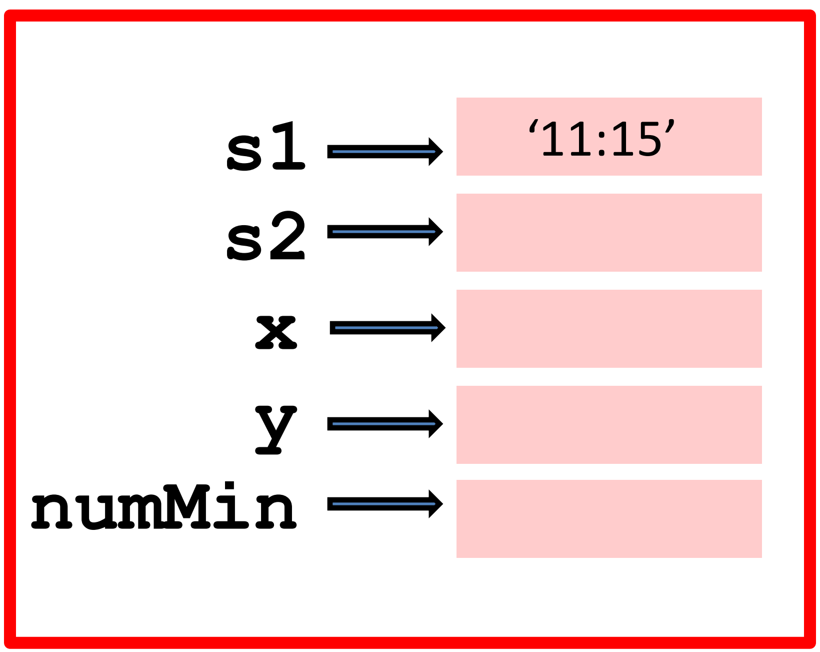
```
● s1 = '11:15'
  s2 = '12:05'
  x = T(s1)
  y = T(s2)
  if y>=x:
      numMin = y-x
  else:
      numMin = (y+720)-x
  print numMin
```

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



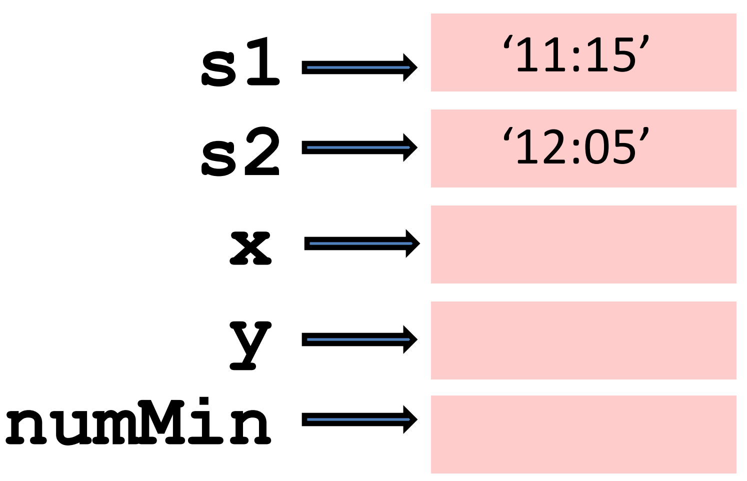
This box is called Global Space. It includes all the variables associated with the script.

```
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
```



```
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
```



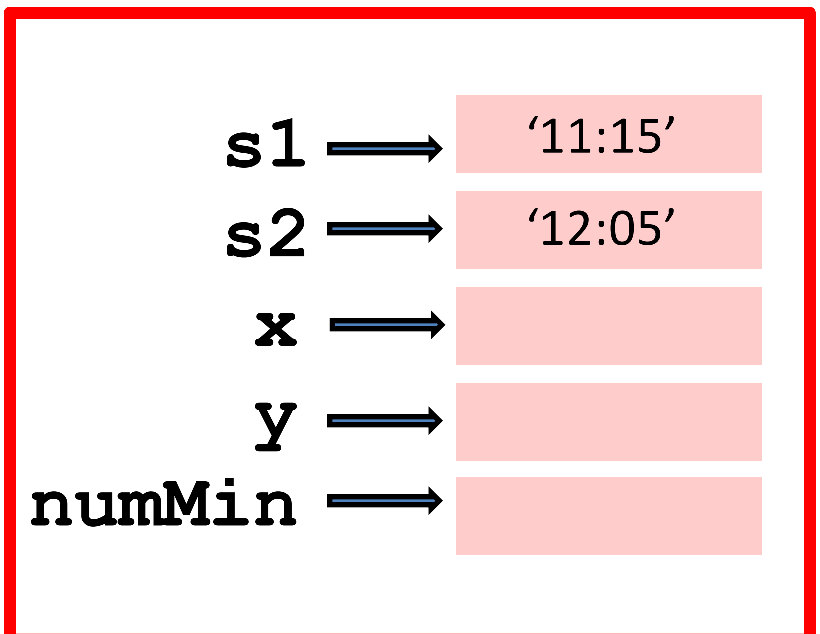
Function call

The defined function T will now be asked to process the value in s1.

Let's track what happens...

```
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
```

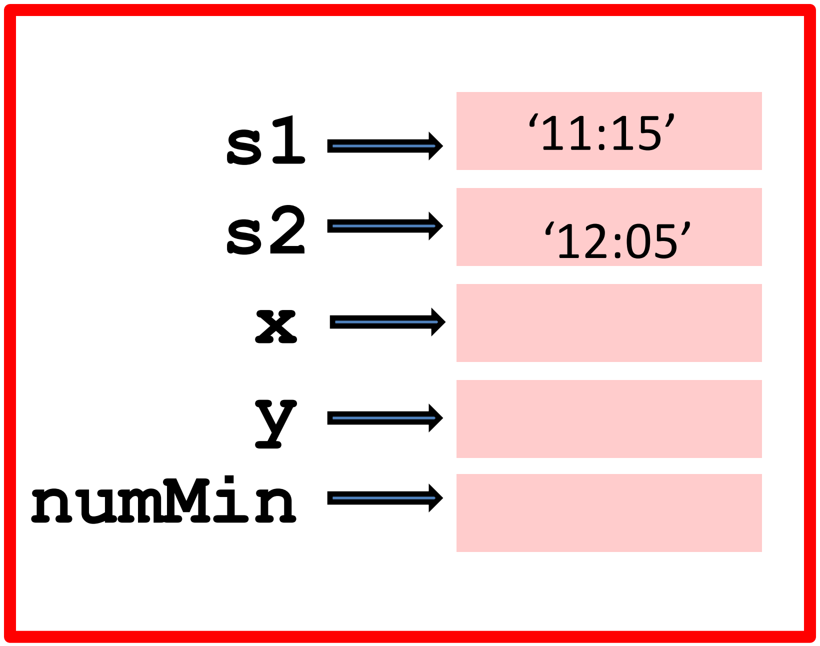


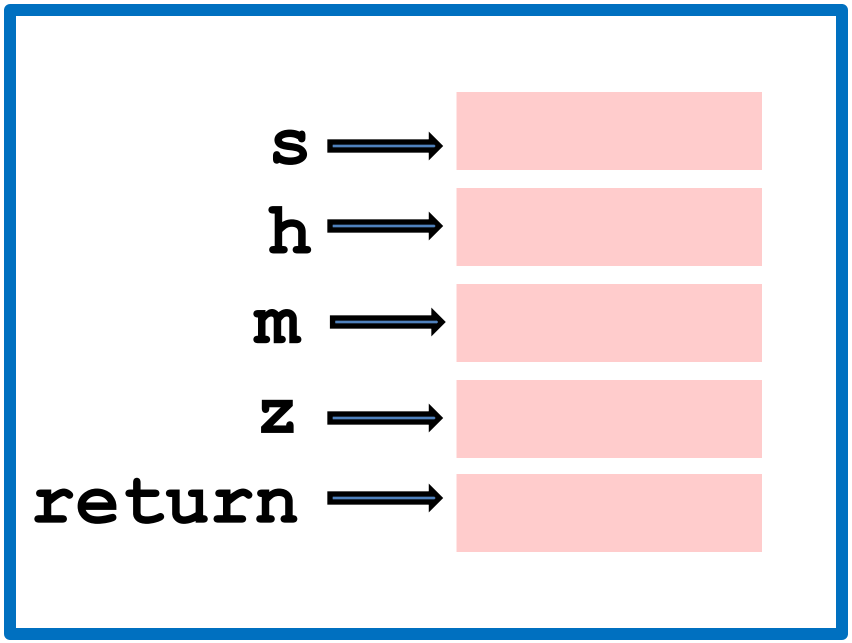
Function call

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

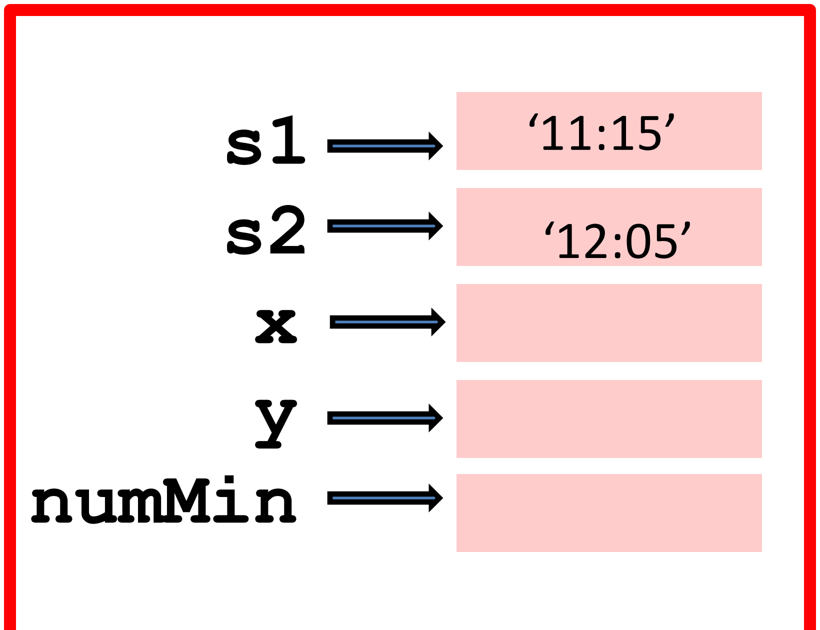


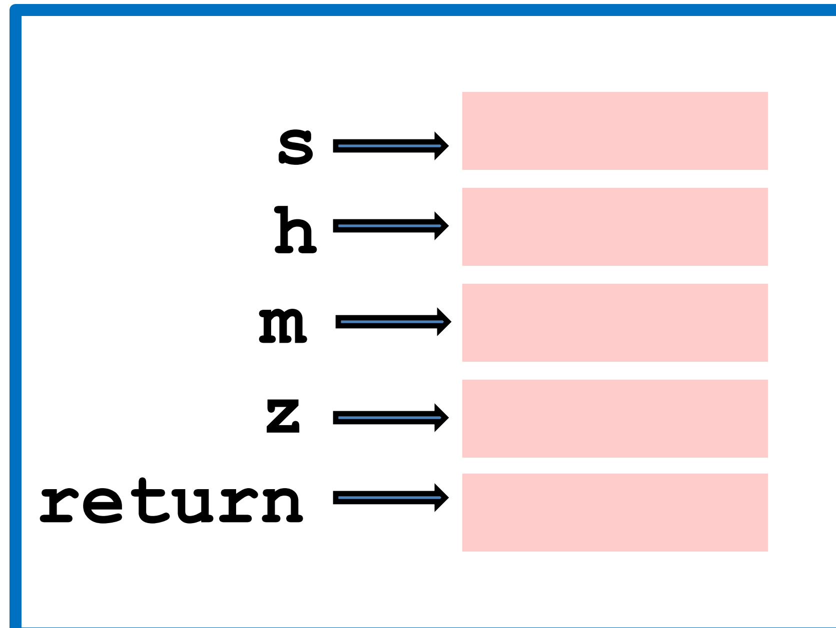


The variable s is the function's parameter

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

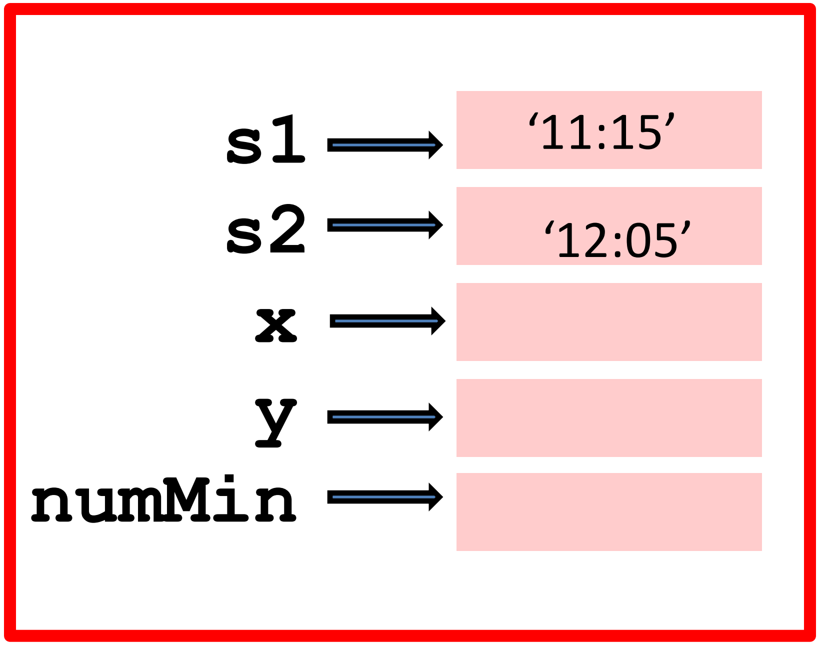


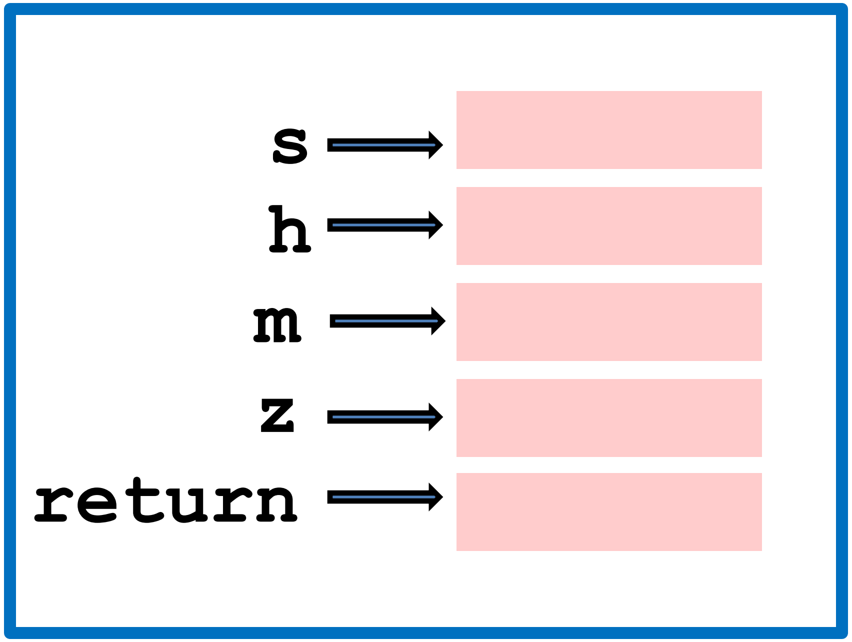


The variables **h**, **m**, and **z** is the function's local variables

```
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
```

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

s →	
h →	
m →	
z →	
return →	

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
```

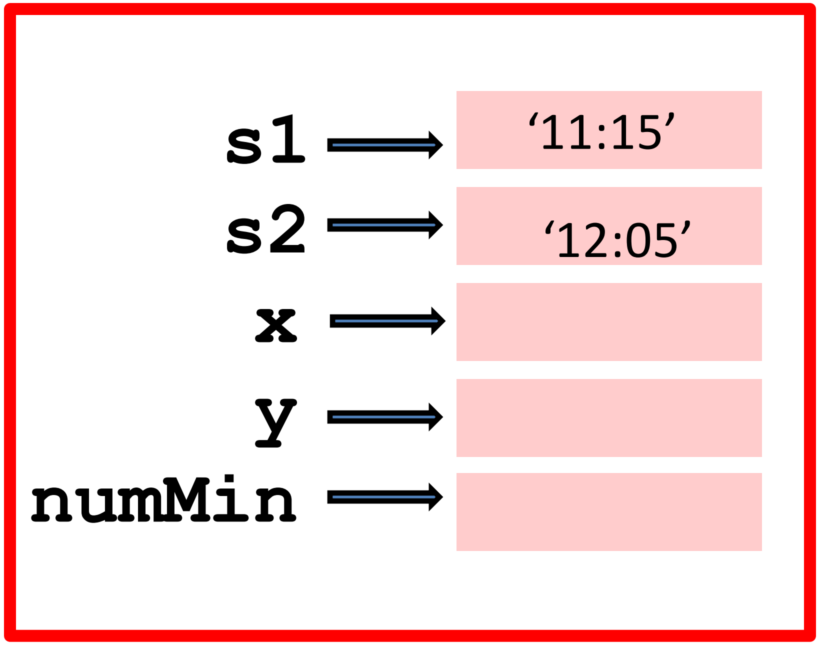
s1 →	'11:15'
s2 →	'12:05'
x →	
y →	
numMin →	

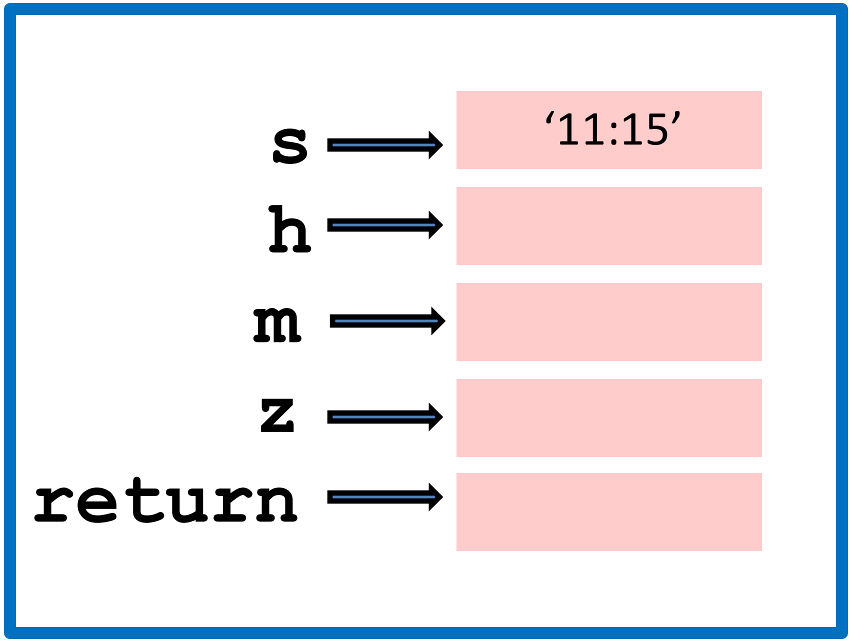
s →	'11:15'
h →	
m →	
z →	
return →	

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
```

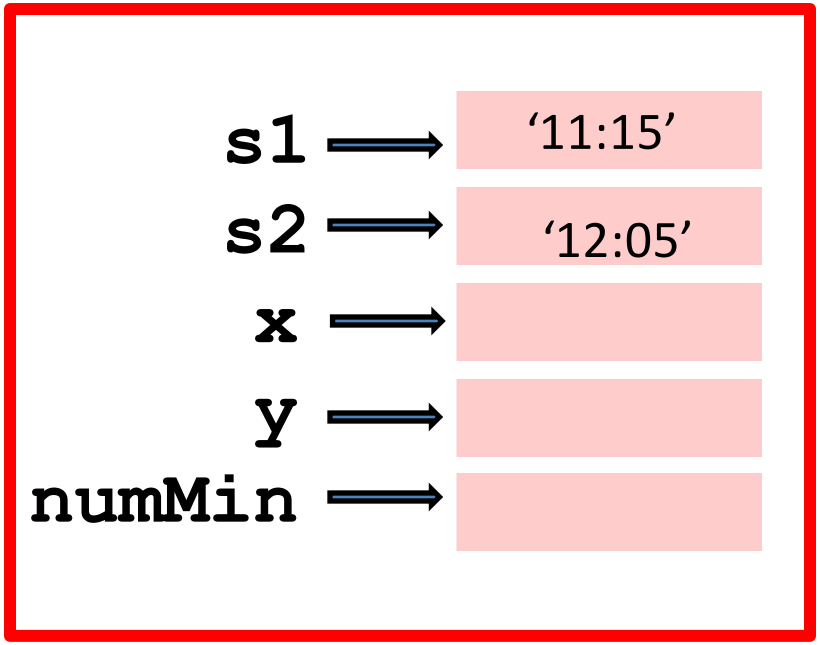


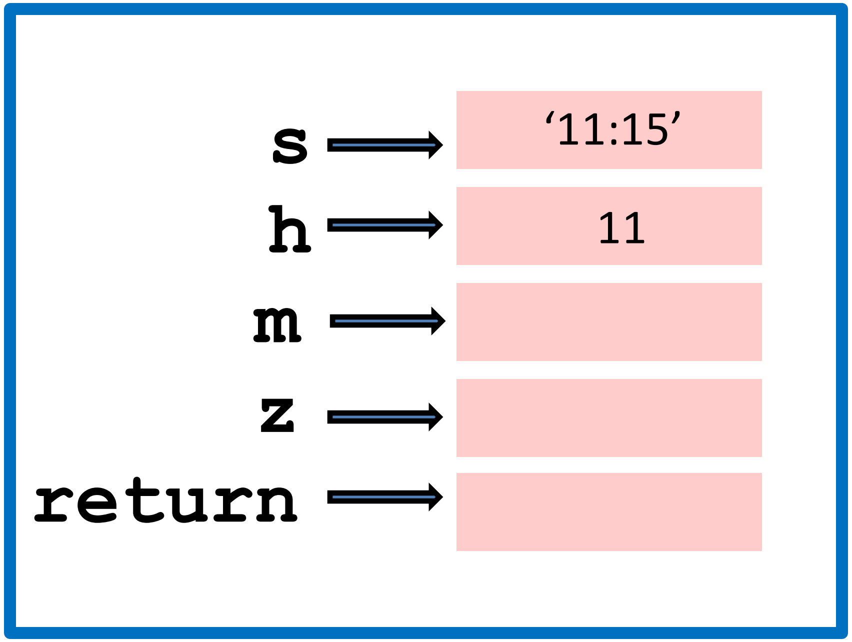


We step through the function body, business as usual.

```
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
```





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
```

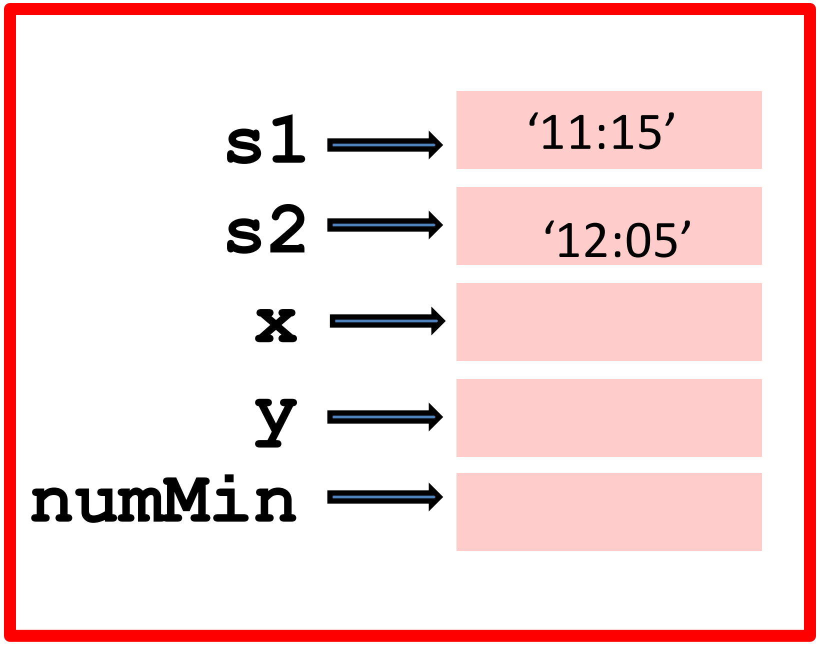
s1 →	‘11:15’
s2 →	‘12:05’
x →	
y →	
numMin →	

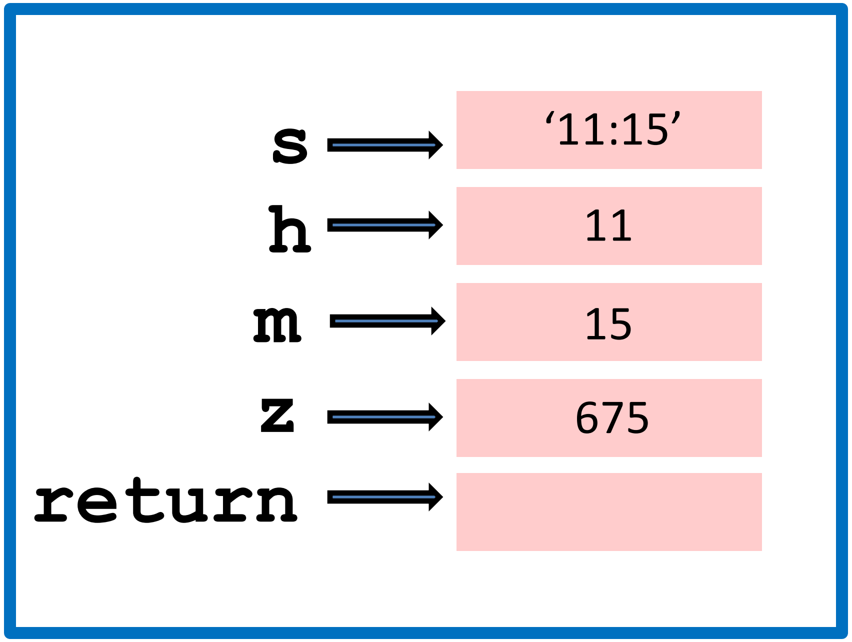
s →	‘11:15’
h →	11
m →	15
z →	
return →	

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
```

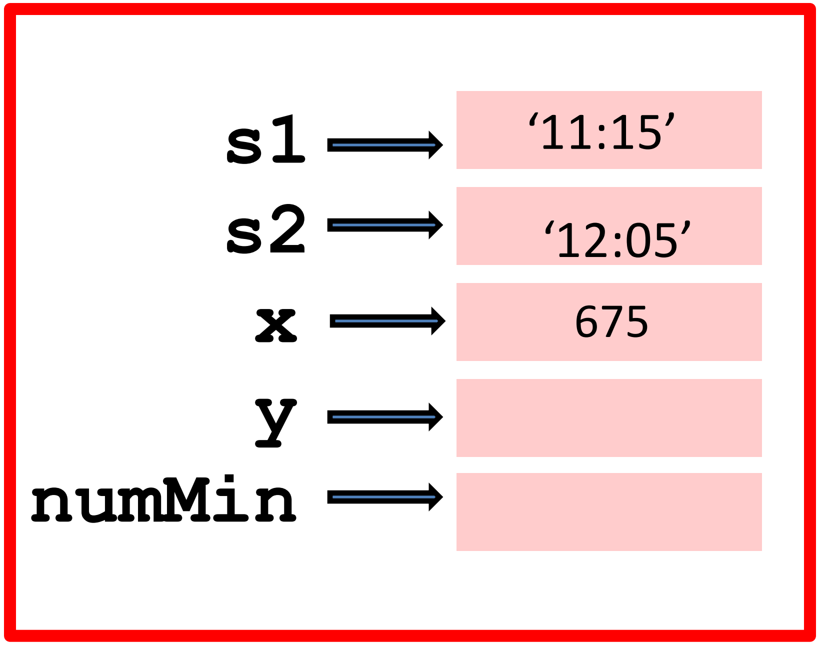
s1 →	‘11:15’
s2 →	‘12:05’
x →	
y →	
numMin →	

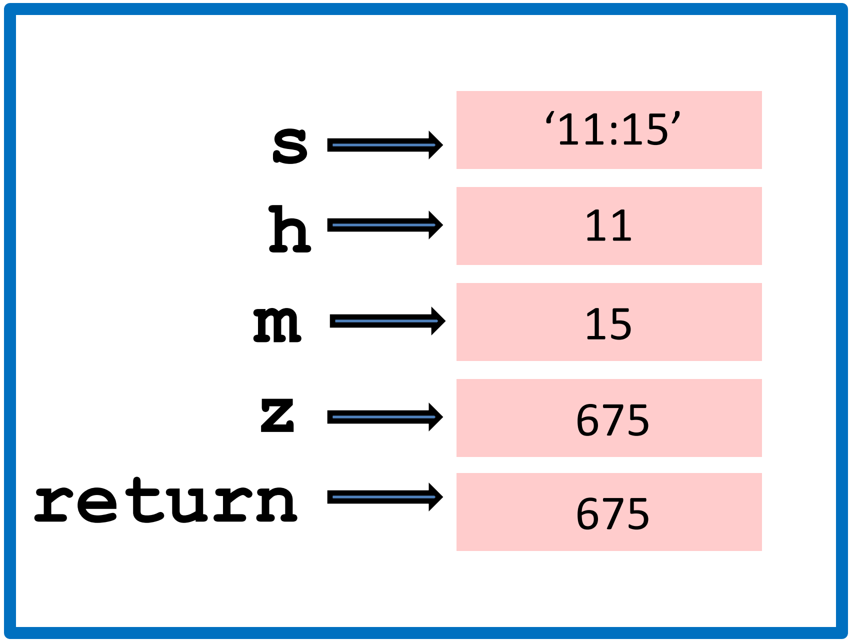
s →	‘11:15’
h →	11
m →	15
z →	675
return →	675

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
```





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
```

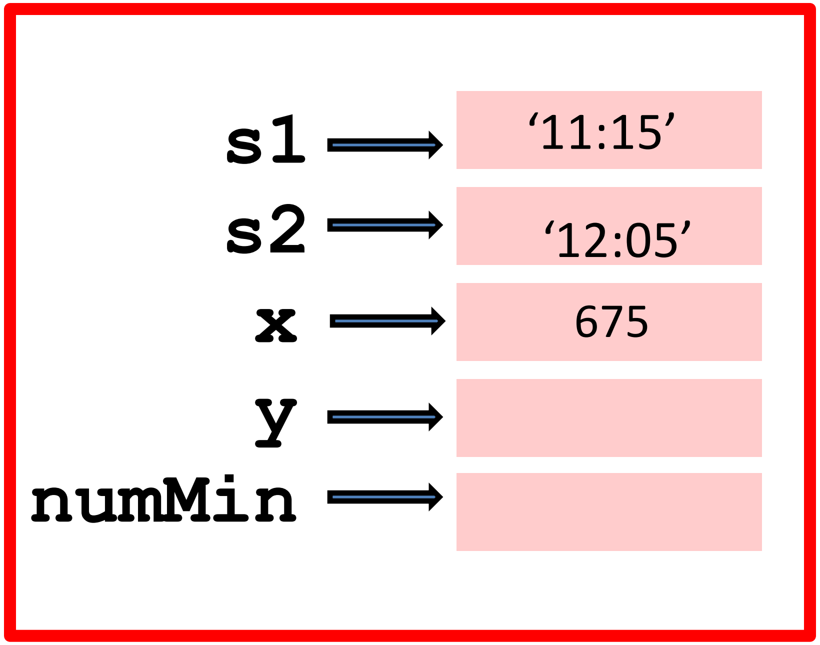
```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

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

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

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
```

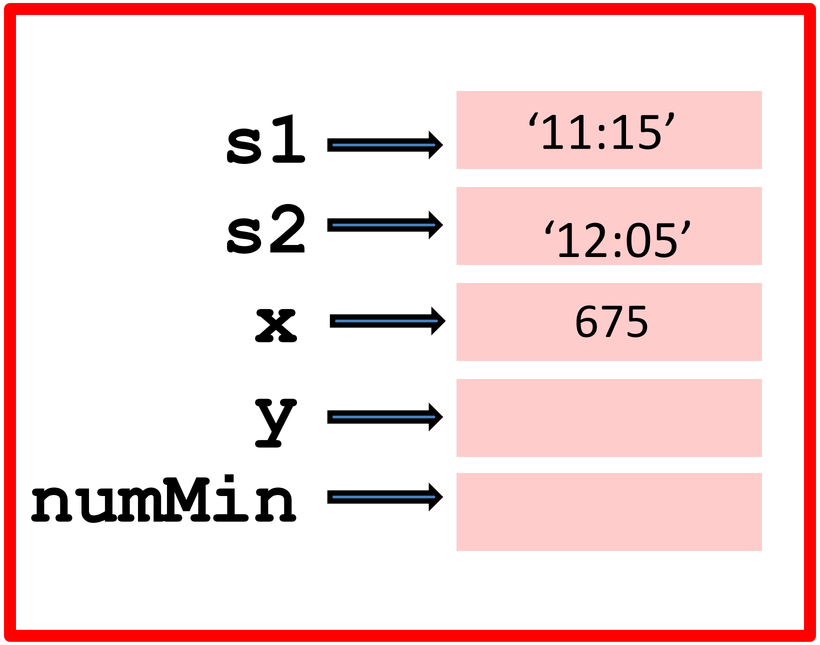


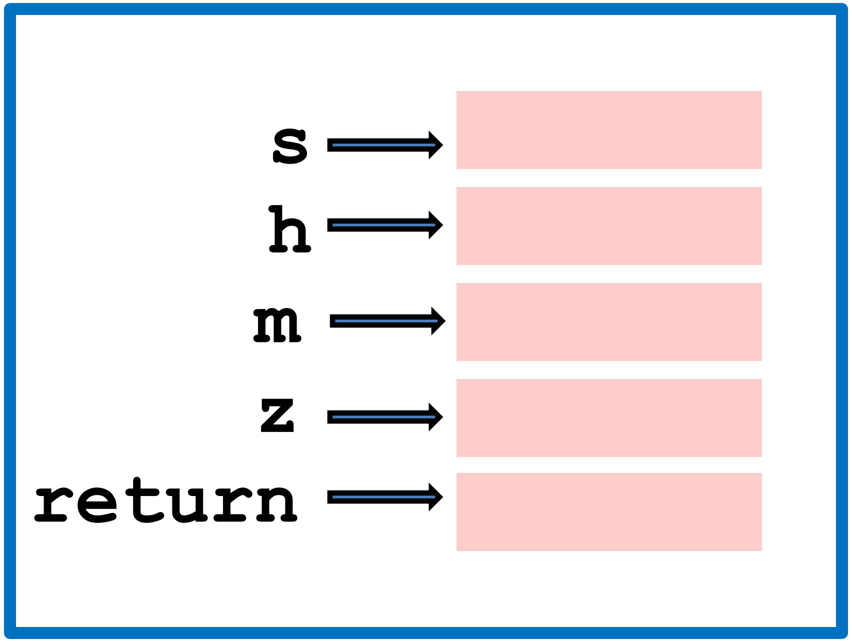
Another function Call!

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
```

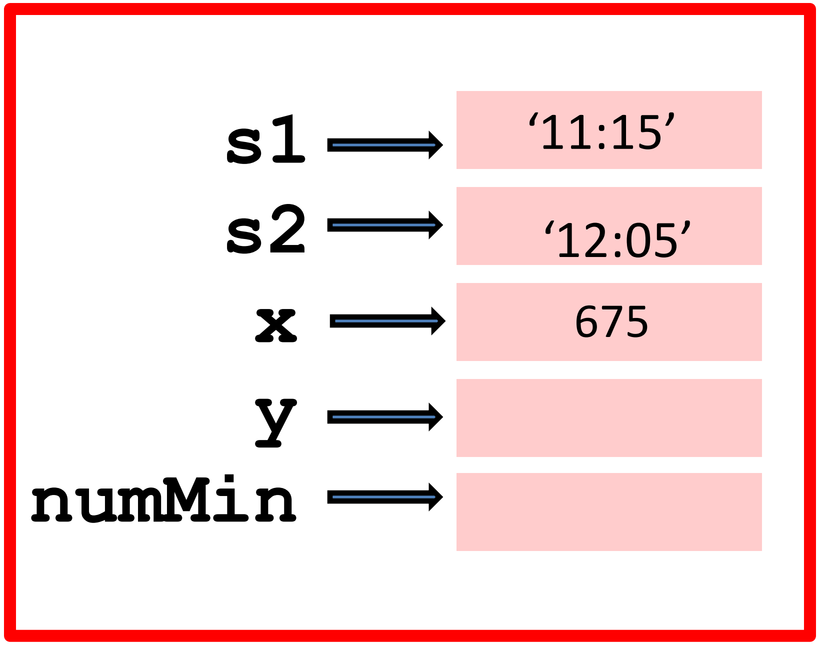


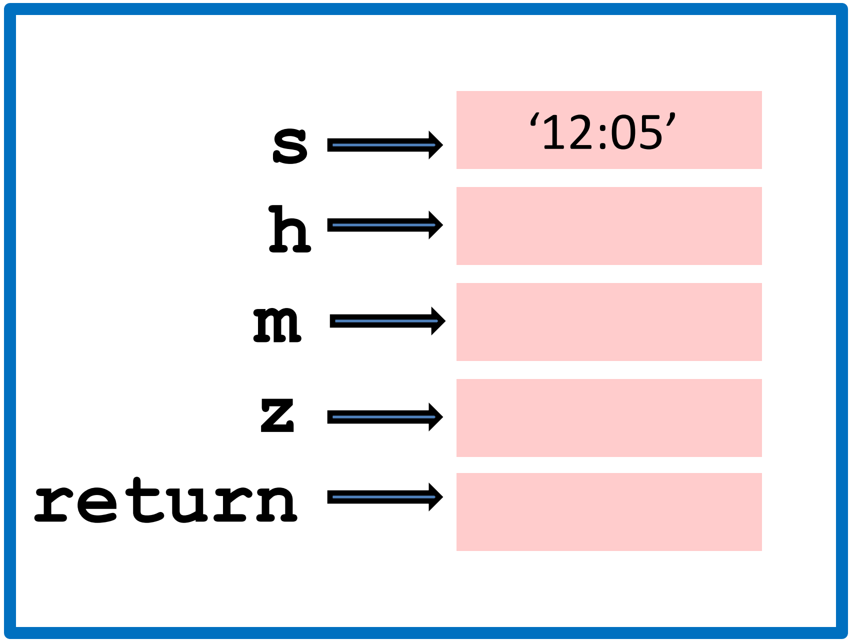


We open up the Call Frame

```
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
```

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

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

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
```

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

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

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 →	

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

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
```

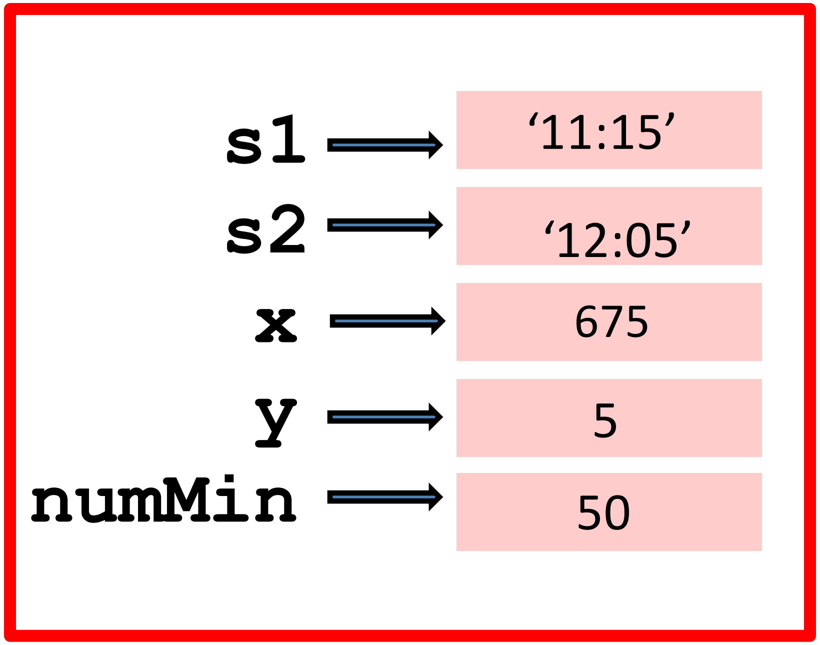
```
def T(s):
    h = int(s[:2])
    m = int(s[3:])
    if h<12:
        z = 60*h+m
    else:
        z = m
    return z
```

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

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

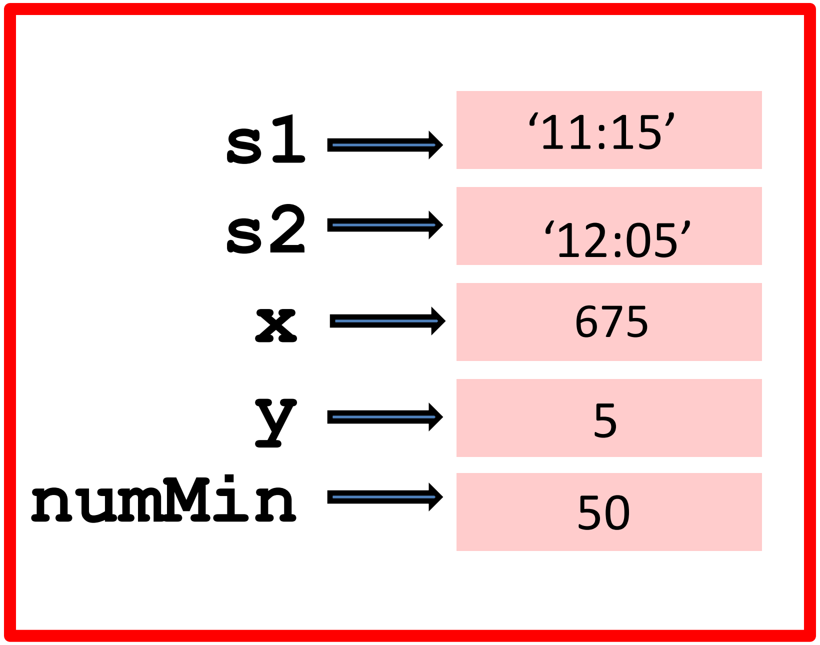
That value is sent back to the red dot.

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



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.