- Previous lecture
  - User-defined functions
    - Function header
    - Input parameters and return variables
- Today's lecture
  - User-defined functions
    - local memory space
    - Subfunction
  - 1-dimensional array and plot
- Announcement
  - Discussion this week in classrooms as listed in Student Center
  - Make use of consulting/office hours

General form of a user-defined function

```
function [out1, out2, …]= functionName (in1, in2, …)
% 1-line comment to describe the function
% Additional description of function

    Executable code that at some point assigns
    values to output parameters out1, out2, …
```

- *in1*, *in2*, … are defined when the function begins execution. Variables *in1*, *in2*, … are called function *parameters* and they hold the function *arguments* used when the function is invoked (called).
- *out1*, *out2*, … are not defined until the executable code in the function assigns values to them.

Returning a value ≠ printing a value

You have this function:

```
function  [x, y] = polar2xy(r, theta)
% Convert polar coordinates (r,theta) to
% Cartesian coordinates (x,y).  Theta in degrees.
…
```

Code to call the above function:

```
% Convert polar (r1,t1) to Cartesian (x1,y1)
r1= 1;   t1= 30;
[x1, y1]= polar2xy(r1, t1);
plot(x1, y1, 'b*')
…
```

Returning a value ≠ printing a value

You have this function:

```
function [x, y] = polar2xy(r, theta)
% Convert polar coordinates (r,theta) to
% Cartesian coordinates (x,y).  Theta in degrees.
... fprintf('(%.1f, %.1f)\n', x, y)
```

Function prints instead of returns values

Code to call the above function:

```
% Convert polar (r1,t1) to Cartesian (x1,y1)
r1= 1;  t1= 30;
[x1, y1]= polar2xy(r1, t1);
plot(x1, y1, 'b*')
```

Not possible to do

Now, although you can see the coordinates, this script cannot use them.

Given this function:

```
function m = convertLength(ft,in)
% Convert length from feet (ft) and inches (in)
% to meters (m).

   . . .
```

How many proper calls to convertLength are shown below?

```
% Given f and n
d= convertLength(f,n);
d= convertLength(f*12+n);
d= convertLength(f+n/12);
x= min(convertLength(f,n), 1);
y= convertLength(pi*(f+n/12)^2);
```

A: 1 B: 2 C: 3 D: 4 E: 5 or 0

Comments in functions

- Block of comments after the function header is printed whenever a user types

  `help <functionName>`

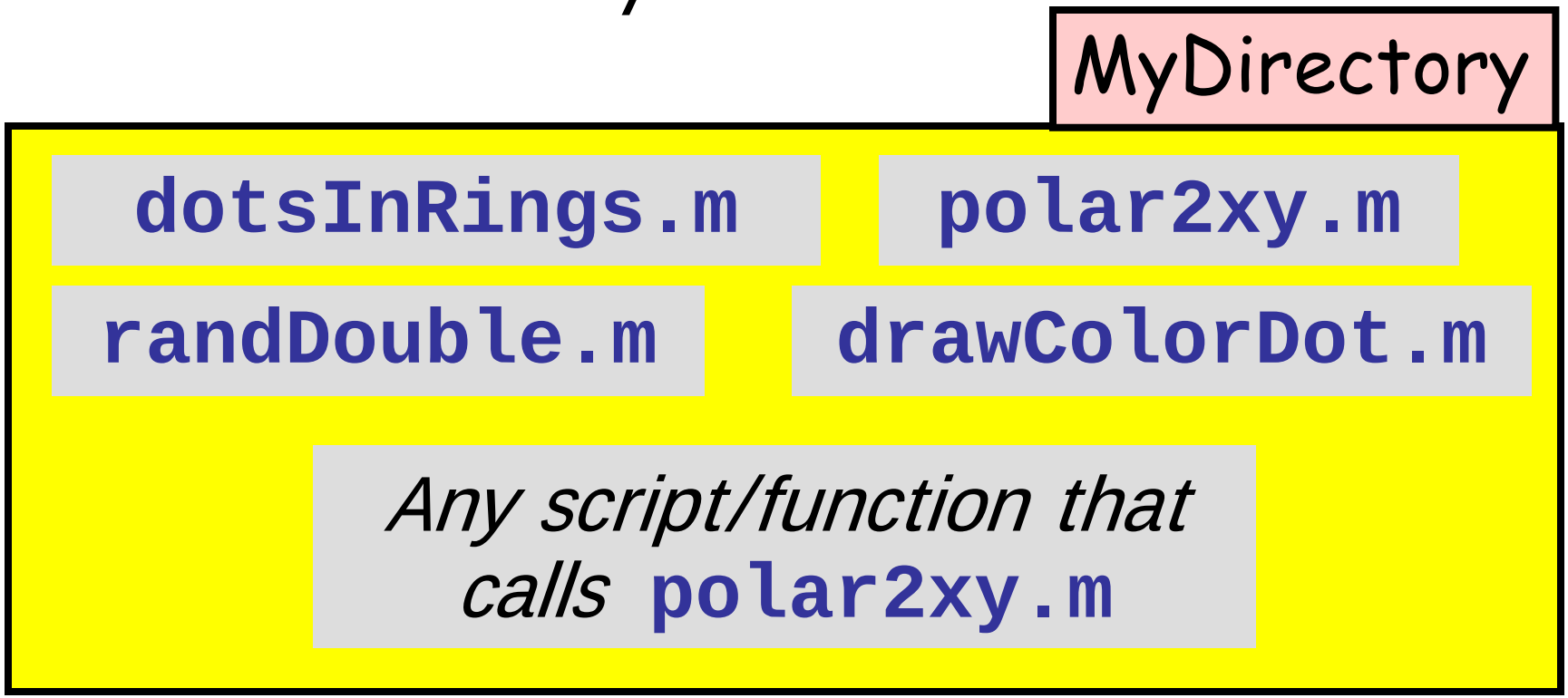
  at the Command Window
- 1st line of this comment block is searched whenever a user types

  `lookfor <someWord>`

  at the Command Window
- Every function should have a comment block after the function header that says what the function does concisely

Accessing your functions

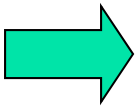
For now*, put your related functions and scripts in the same directory.



*The **path** function gives greater flexibility

Why write user-defined function?

- Easy code re-use—great for "common" tasks
- A function can be tested independently easily
- Keep a driver program clean by keeping detail code in functions—separate, non-interacting files



Facilitate top-down design

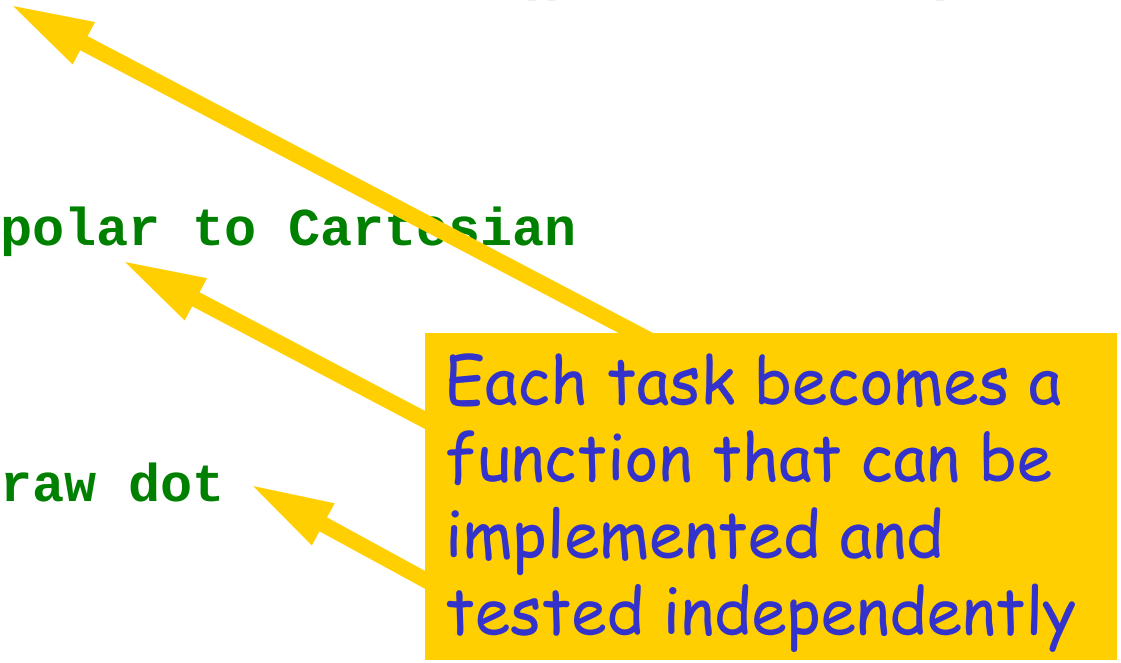
```
c= input('How many concentric rings? ');
d= input('How many dots? ');

% Put dots btwn circles with radii rRing and (rRing-1)
for rRing= 1:c
  % Draw d dots
  for count= 1:d

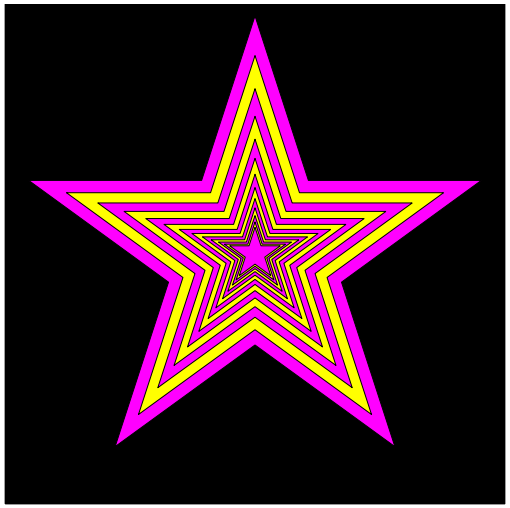
    % Generate random dot location (polar coord.)
    theta=_______
    r=_______

    % Convert from polar to Cartesian
    x=_______
    y=_______

    % Use plot to draw dot
  end
end
```



Facilitates top-down design



1. Focus on how to draw the figure given just a specification of what the function **`DrawStar`** does.

2. Figure out how to implement **`DrawStar`**.

To specify a function…

… you describe how to use it, e.g.,

```
function DrawStar(xc,yc,r,c)
% Adds a 5-pointed star to the
% figure window. Star has radius r,
% center(xc,yc) and color c where c
% is one of 'r', 'g', 'y', etc.
```

Given the specification, the user of the function doesn't need to know the detail of the function—they can just use it!

To implement a function…

… you write the code so that the function "lives up to" the specification. E.g.,

```
r2 = r/(2*(1+sin(pi/10)));
for k=1:11
    theta = (2*k-1)*pi/10;
    if 2*floor(k/2)~=k
      x(k) = xc + r*cos(theta);
      y(k) = yc + r*sin(theta);
    else
      x(k) = xc + r2*cos(theta);
      y(k) = yc + r2*sin(theta);
    end
end
fill(x,y,c)
```

Don't worry—you'll learn more about graphics functions and vectors soon.

Why write user-defined function?

- Easy code re-use—great for "common" tasks
- A function can be tested independently easily
- Keep a driver program clean by keeping detail code in functions—separate, non-interacting files
- Facilitate top-down design
- Software management

Software Management

Today:

I write a function

`EPerimeter(a,b)`

that computes the perimeter of the ellipse

$$\left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2 = 1$$

Software Management

During this year :

You write software that makes extensive use of

```
EPerimeter(a,b)
```

Imagine hundreds of programs each with several lines that reference `EPerimeter`

Software Management

Next year:

I discover a more efficient way to approximate ellipse perimeters. I change the implementation of

```
EPerimeter(a,b)
```

You do not have to change your software at all.

What will be printed?

A: -3 B: 3 C: error

```
% Script file
p= -3;
q= absolute(p);
disp(p)
```

```
function q = absolute(p)
% q is absolute value of p
if (p<0)
   p= -p;
end
q= p;
```

What will be printed?

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% Script file
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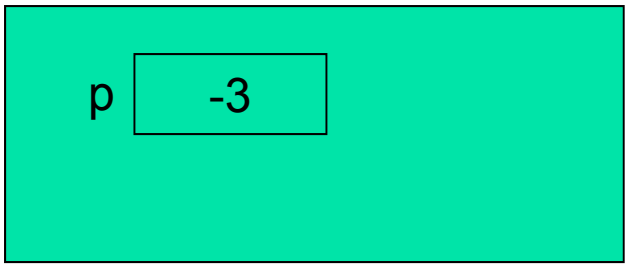
Command Window Workspace



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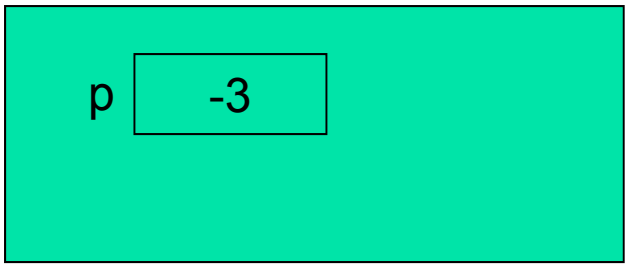

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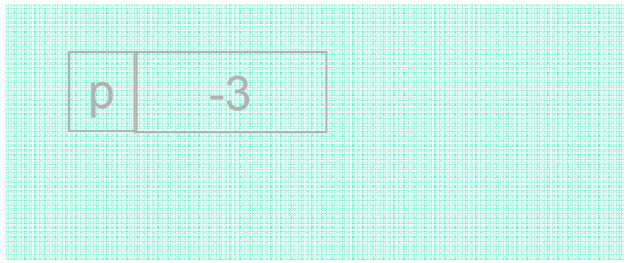
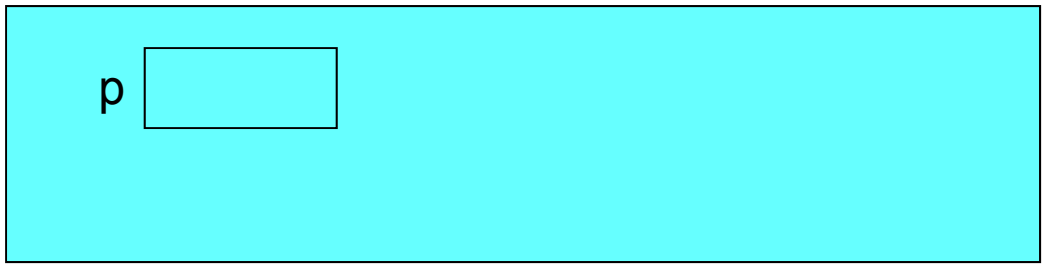


Function absolute's Workspace



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Command Window Workspace

p	-3

Function absolute's Workspace

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Command Window Workspace

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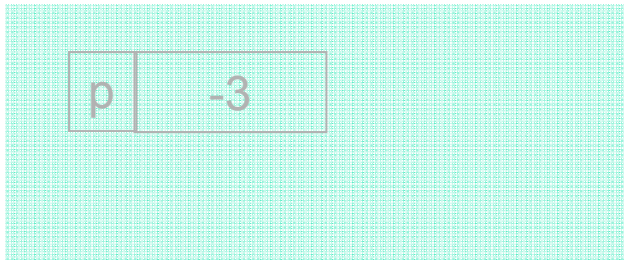

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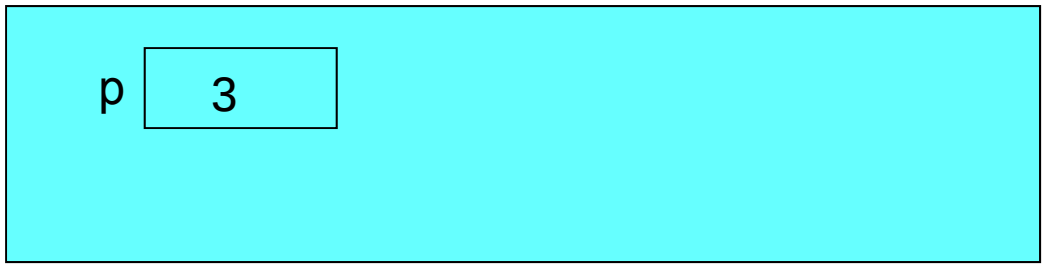

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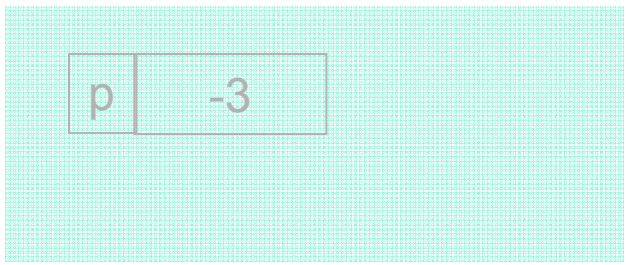

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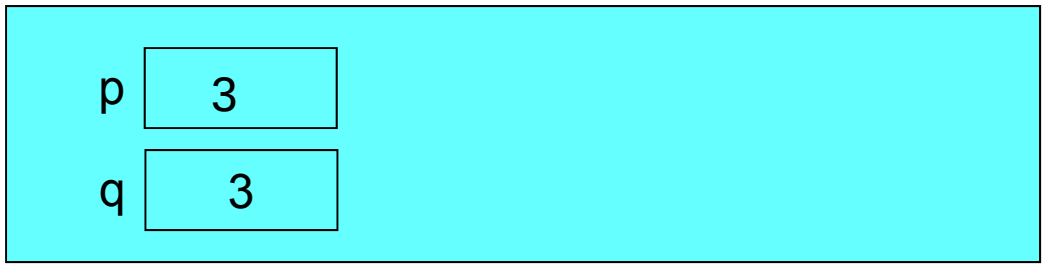

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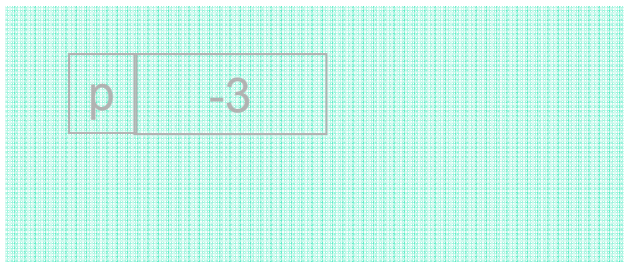

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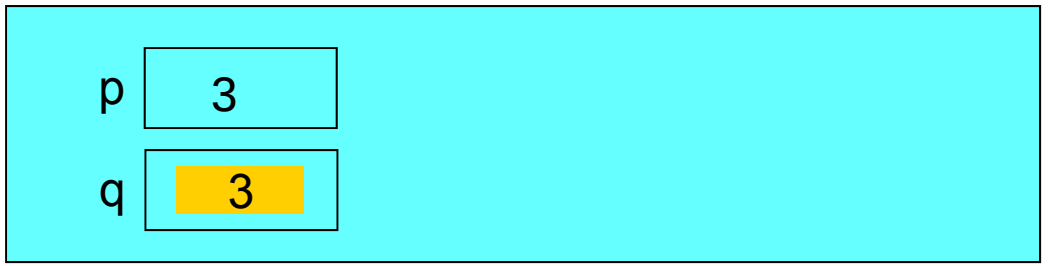

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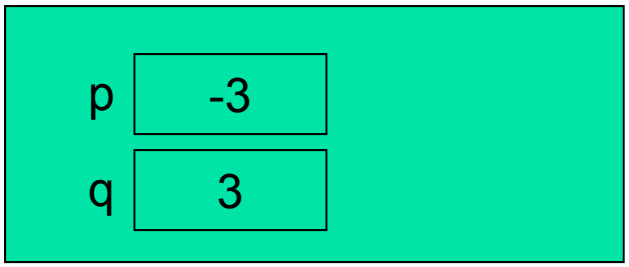
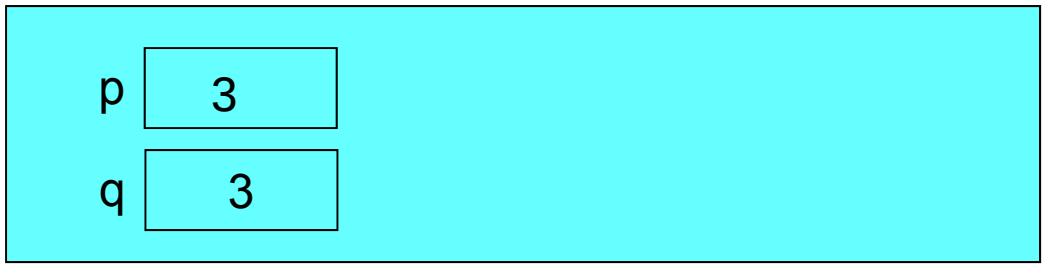


Function absolute's Workspace



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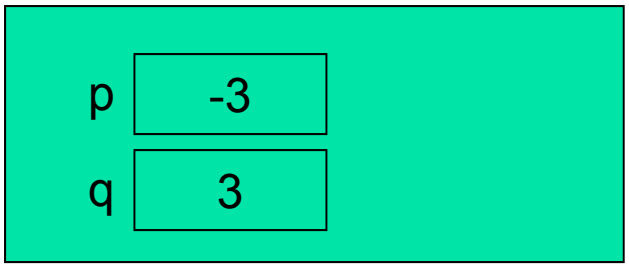

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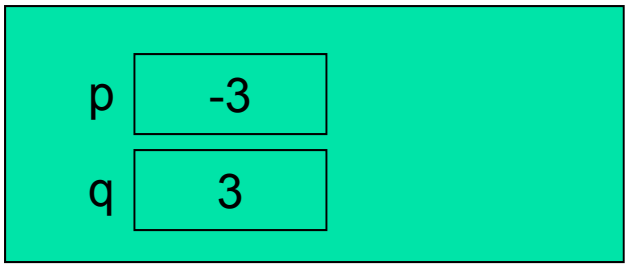

REVIEW!!!

```
% Script file
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disp(p)
```

```
function q = absolute(p)
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end
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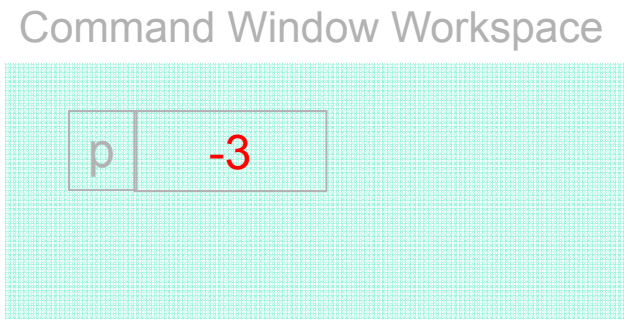
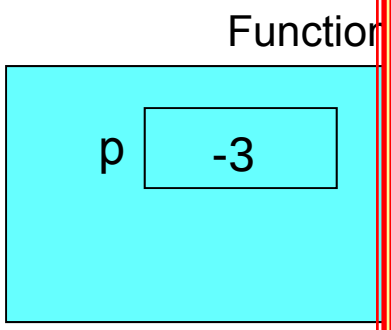
```





A value is passed to the function parameter when the function is called.

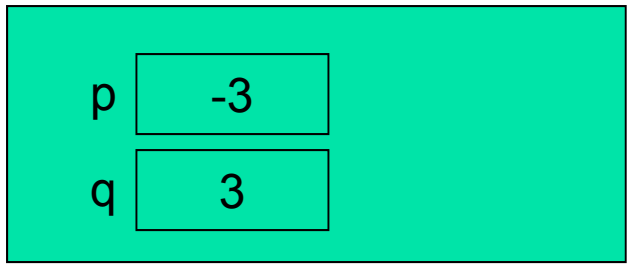
The two variables, both called p, live in different memory space and do not interfere.

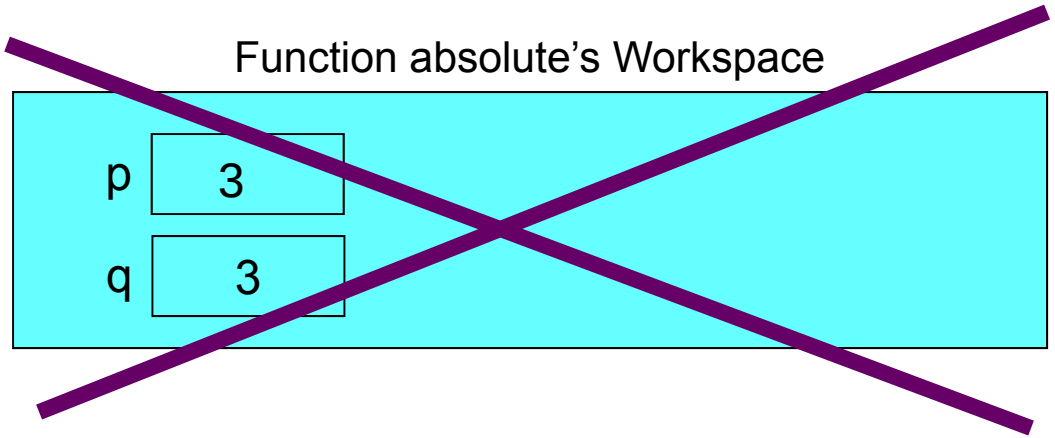
REVIEW!!!!

```
% Script file
p= -3;
q= absolute(p);
disp(p)
```

```
function q = absol
% q is the absolute
if (p<0)
   p= -p;
end
q= p;
```

When a function reaches the end of execution (and returns the output argument), the function space—local space—is deleted.





What is the output?

```
x = 1;
x = f(x+1);
y = x+1;
disp(y)
```

```
function y = f(x)
x = x+1;
y = x+1;
```

A: 1 | B: 2 | C: 3 | D: 4 | E: 5

What is the output?

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x = 1;
x = f(x+1);
y = x+1;
disp(y)
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```
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A: 1

B: 2

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D: 4

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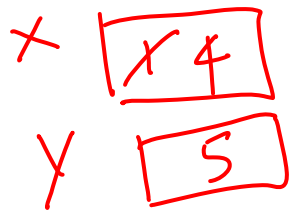

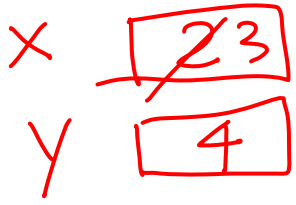

Execute the statement `y= foo(x)`

- Matlab looks for a function called foo (m-file called foo.m)
- Argument (value of x) is copied into function foo's local parameter
  - called "pass-by-value," one of several argument passing schemes used by programming languages
- Function code executes within its own workspace
- At the end, the function's output argument (value) is sent from the function to the place that calls the function. E.g., the value is assigned to y.
- Function's workspace is deleted
  - If foo is called again, it starts with a new, empty workspace

Subfunction

- There can be more than one function in an M-file
- top function is the main function and has the name of the file
- remaining functions are subfunctions, accessible only by the functions in the same m-file
- Each (sub)function in the file begins with a function header
- Keyword **end** is not necessary at the end of a (sub)function