- Previous lecture:
  - Introduction to objects and classes
  - Value vs. reference
  - Instantiating an object; accessing its properties and methods
- Today's lecture:
  - Objects are passed by reference to functions
  - Details on class definition
    - Constructor
    - Methods
    - Attributes for properties and methods
- Announcements:
  - Prelim 2 will be returned on Tues

To specify the properties & methods of an object is to define its class

- An interval has two endpoints
- We may want to perform these actions:
  - scale and shift individual intervals
  - Determine whether two intervals overlap
  - Add and subtract two intervals

```
classdef Interval < handle

  properties
    left
    right
  end

  methods
    function scale(self, f)
      …
    end

    function Inter = overlap(self, other)
      …
    end

    function Inter = add(self, other)
      …
    end

    …

  end

end
```

classdef syntax summary

A class file begins with keyword classdef:

classdef *classname* < handle

The class specifies handle objects

Constructor returns a reference to the class object

Each instance method's first parameter must be a reference to the instance (object) itself

Use keyword end for keywords classdef, properties, methods, function.

Properties

Constructor

Instance methods (functions)

```
classdef  Interval < handle
% An Interval has a left end and a right end

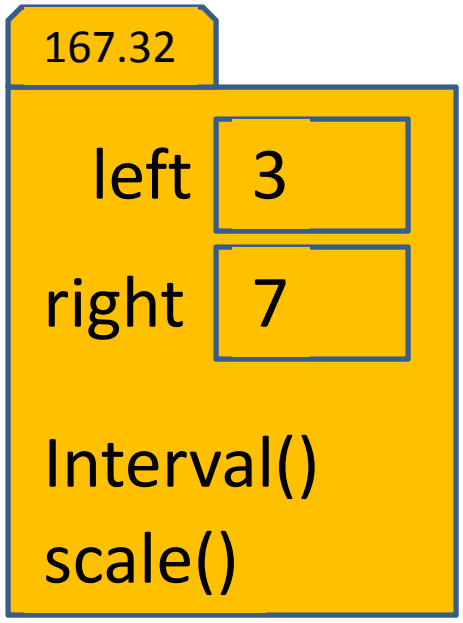
   properties
      left
      right
   end

   methods
      function Inter = Interval(lt, rt)
      % Constructor:  construct an Interval obj
         Inter.left= lt;
         Inter.right= rt;
      end

      function scale(self, f)
      % Scale the interval by a factor f
         w= self.right - self.left;
         self.right= self.left + w*f;
      end
   end
end
```

Simplified Interval class

To create an Interval object, use its class name as a function call: p = Interval(3,7)




```
classdef  Interval < handle
% An Interval has a left end and a right end

   properties
     left
     right
   end

   methods
     function Inter = Interval(lt, rt)
     % Constructor:  construct an Interval obj
        Inter.left= lt;
        Inter.right= rt;
     end

     function scale(self, f)
     % Scale the interval by a factor f
        w= self.right - self.left;
        self.right= self.left + w*f;
     end
   end
end
```

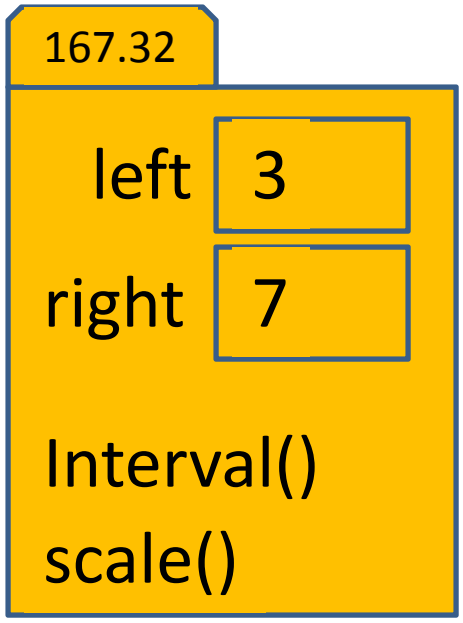
The *constructor* method

To create an Interval object, use its class name as a function call: p = Interval(3,7)

```
classdef Interval < handle
% An Interval has a left end and a right end

  properties
    left
    right
  end

  methods
    function Inter = Interval(lt, rt)
    % Constructor:  construct an Interval obj
       Inter.left= lt;
       Inter.right= rt;
    end
```



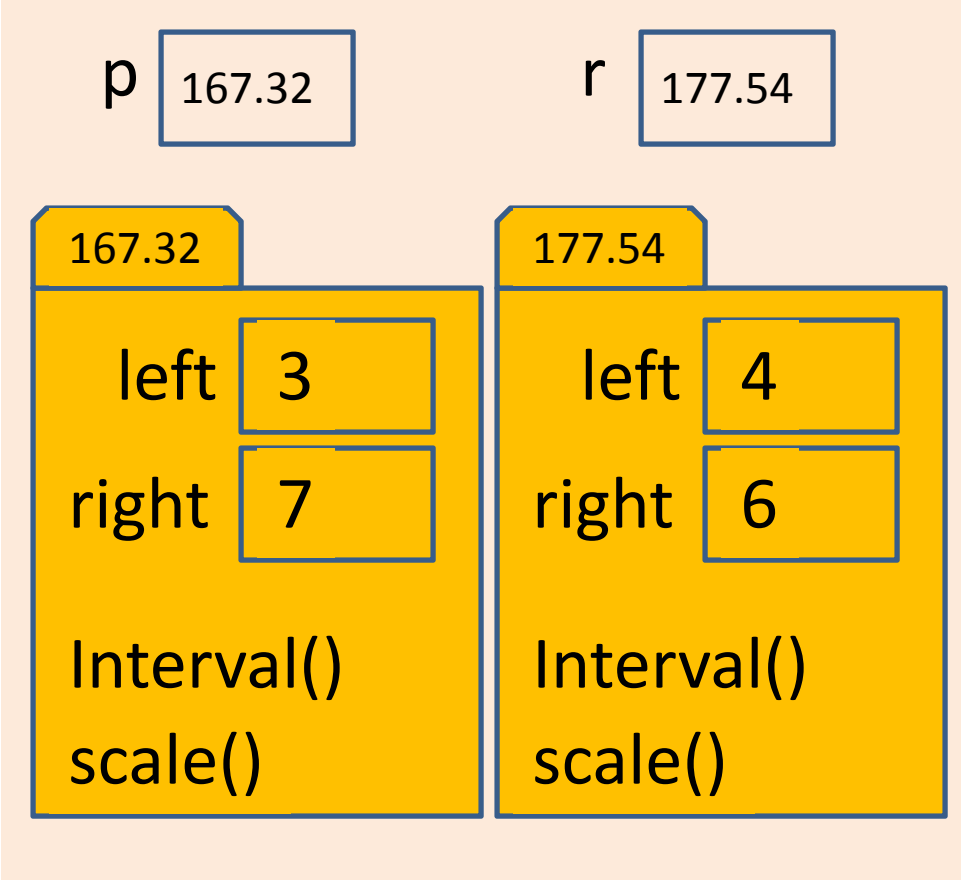
The *constructor* is a special method whose main jobs are to

- compute the handle of the new object,
- execute the function code (to assign values to properties), and
- return the handle of the object.

Constructor has the name of the class

A handle object is referenced by its handle

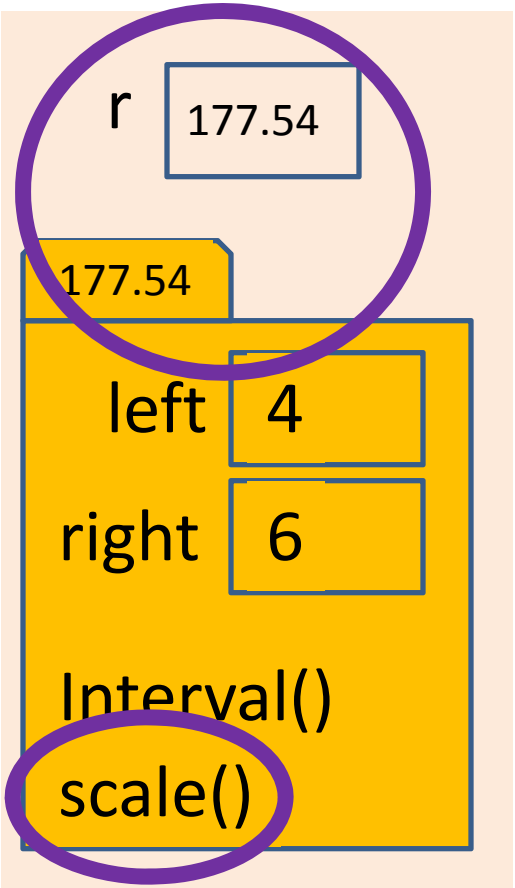
```
p = Interval(3,7);
r = Interval(4,6);
```



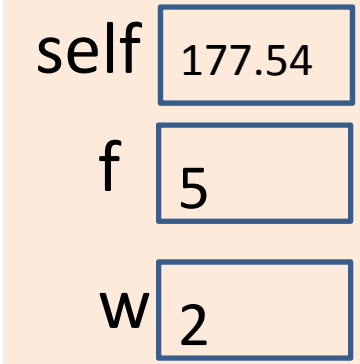
A handle, also called a reference, is like an address; it indicates the memory location where the object is stored.

Executing an instance method

```
r = Interval(4,6);
r.scale(5)
disp(r.right) %What will it be?
```



Function space of scale




```
classdef  Interval < handle
% An Interval has a left end and a rig

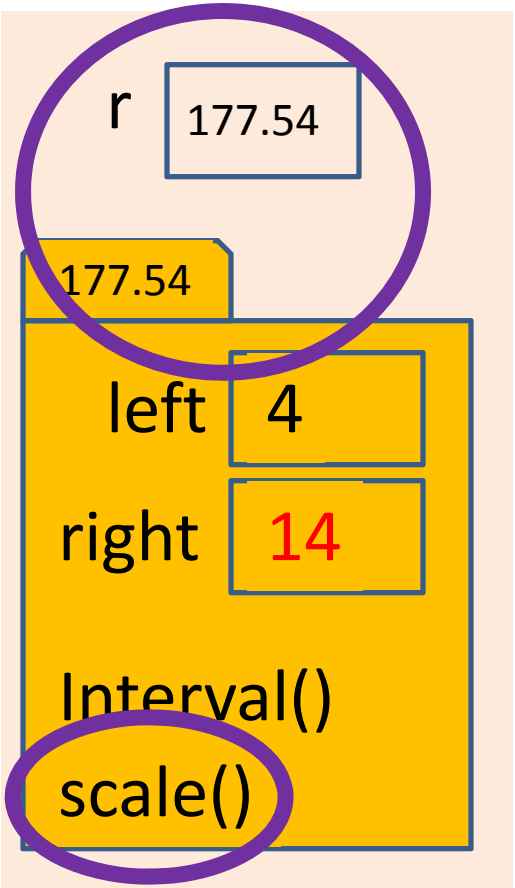
   properties
     left
     right
   end

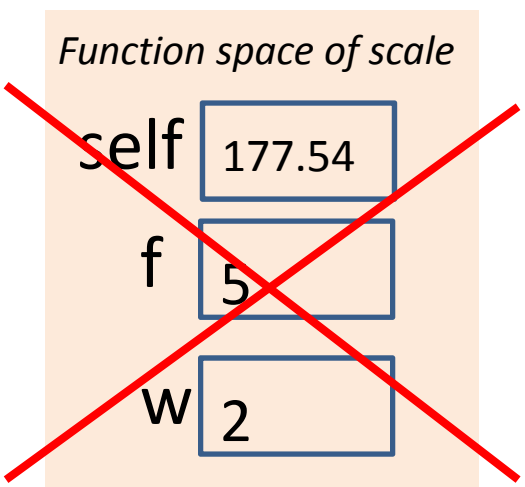
   methods
      function Inter = Interval(lt, rt)
      % Constructor:  construct an Inte
         Inter.left= lt;
         Inter.right= rt;
      end

      function scale(self, f)
      % Scale the interval by a factor f
         w= self.right - self.left;
         self.right= self.left + w*f;
      end
   end
end
```

Object is passed to a function by reference

```
r = Interval(4,6);
r.scale(5)
disp(r.right) % updated value
```



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         Inter.left= lt;
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      end

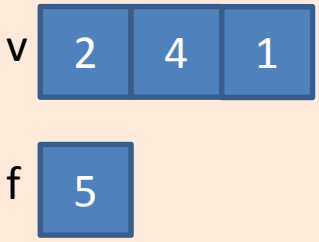
      function scale(self, f)
      % Scale the interval by a factor f
         w= self.right - self.left;
         self.right= self.left + w*f;
      end
```

Objects are passed to functions by reference. Changes to an object's property values made through the local reference (self) stays in the object even after the local reference disappears when the function ends.

Non-objects are passed to a function by value

Command Window workspace

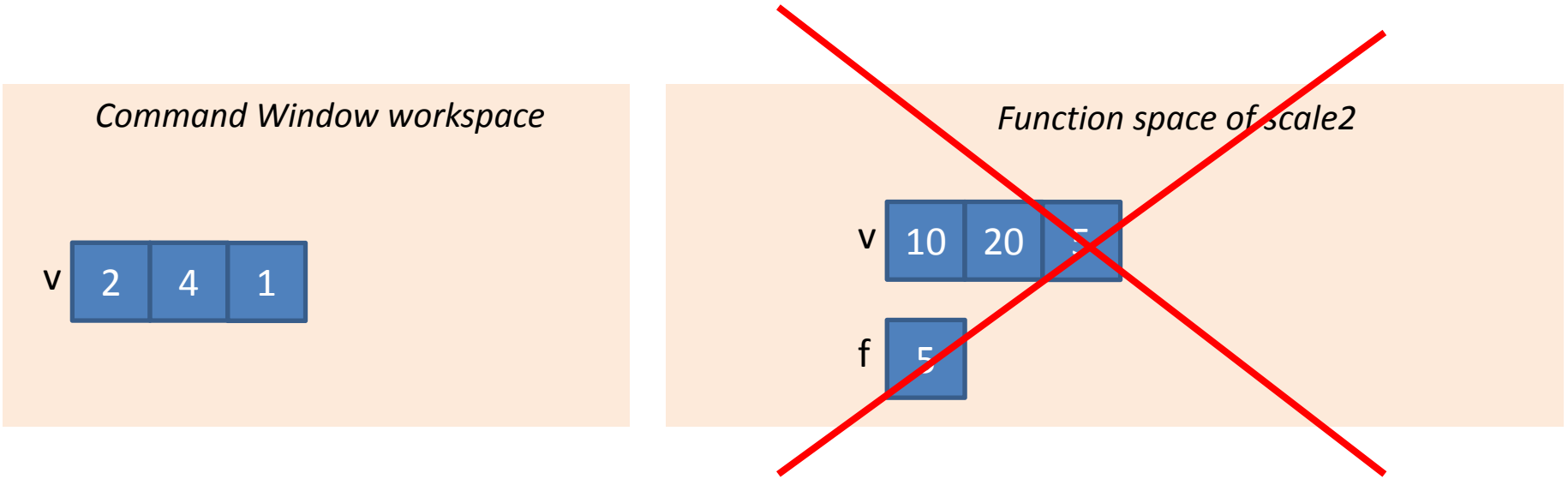
Function space of scale2




```
v= [2 4 1];
scale2(v,5)
disp(v) %???
```

```
function scale2(v,f)
% Scale v by a factor f
v= v*f;
```

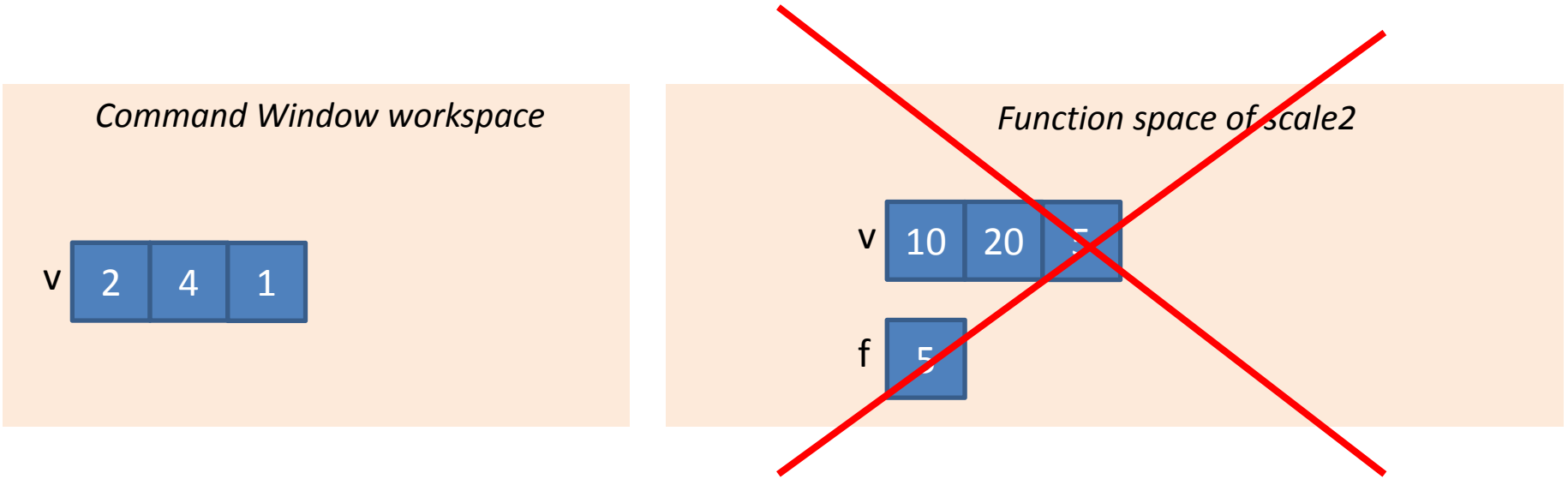
Non-objects are passed to a function by value




```
v= [2 4 1];
scale2(v,5)
disp(v) %???
```

```
function scale2(v,f)
% Scale v by a factor f
v= v*f;
```

Non-objects are passed to a function by value




```
v= [2 4 1];
scale2(v,5)
disp(v) %NO CHANGE
```

```
function scale2(v,f)
% Scale v by a factor f
v= v*f;
```

Objects are passed to a function by reference

```
r = Interval(4,6);
r.scale(5)
disp(r.right) % updated value
```

```
classdef Interval < handle
  :
  methods
    :
    function scale(self, f)
    % Scale the interval by a factor f
      w= self.right - self.left;
      self.right= self.left + w*f;
    end
  end
end
```

```
v= [2 4 1];
scale2(v,5)
disp(v) %NO CHANGE
```

```
function scale2(v,f)
% Scale v by a factor f
v= v*f;
```

Non-objects are passed to a function by value

Syntax for calling an instance method:

<reference>.<method>(<arguments for 2nd thru last parameters>)

```
p = Interval(3,7);
r = Interval(4,6);

yesno= p.isIn(r);
% Explicitly call
% p's isIn method

yesno= isIn(p,r);
% Matlab chooses the
% isIn method of one
% of the parameters.
```

Better!

```
classdef  Interval < handle
 :
 methods
  :
  function scale(self, f)
  % Scale self by a factor f
    w= self.right - self.left;
    self.right= self.left + w*f;
  end

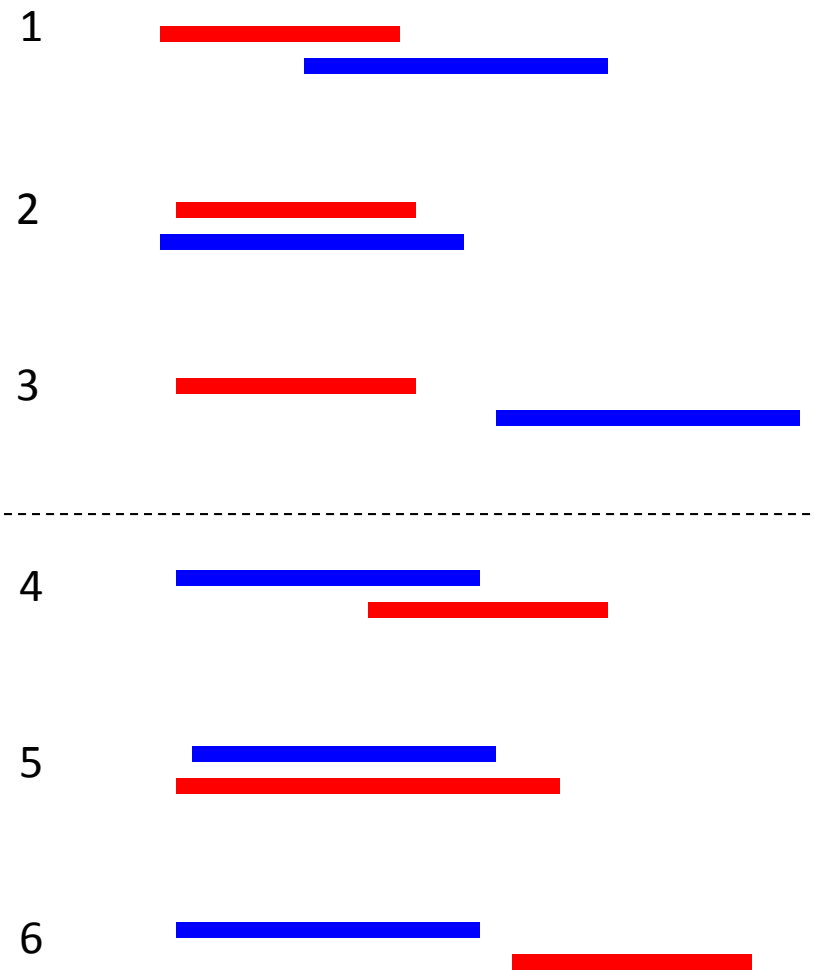
  function tf = isIn(self, other)
  % tf is true if self is in other interval
    tf= self.left>=other.left && ...
        self.right<=other.right;
  end


  end
end
```

Method to find overlap between two Intervals

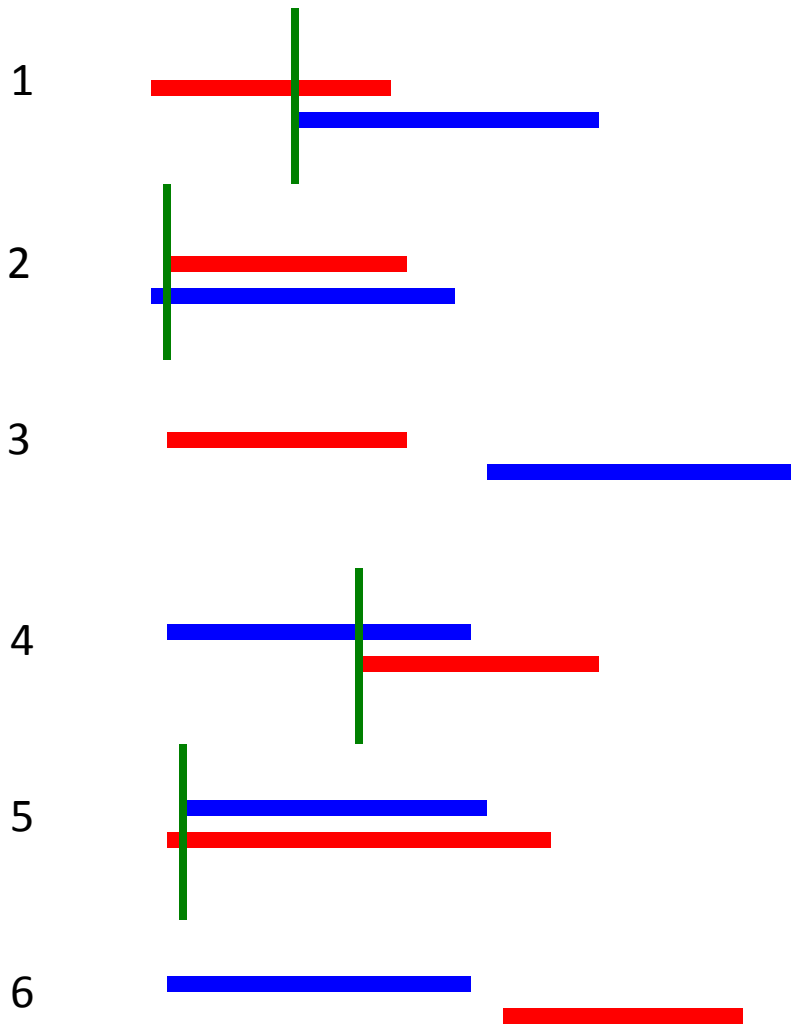
```
function Inter = overlap(self, other)
% Inter is overlapped Interval between self
% and the other Interval. If no overlap then
% self is empty Interval.
```

Compare two intervals

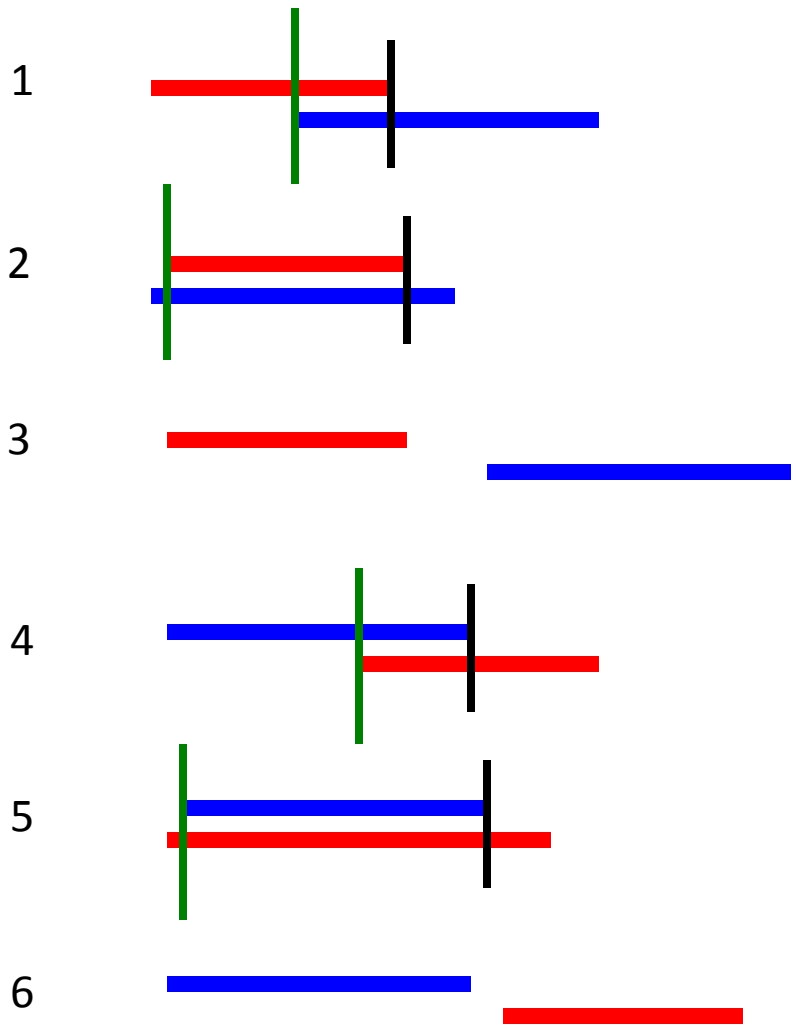


redRight < blueRight

blueRight < redRight

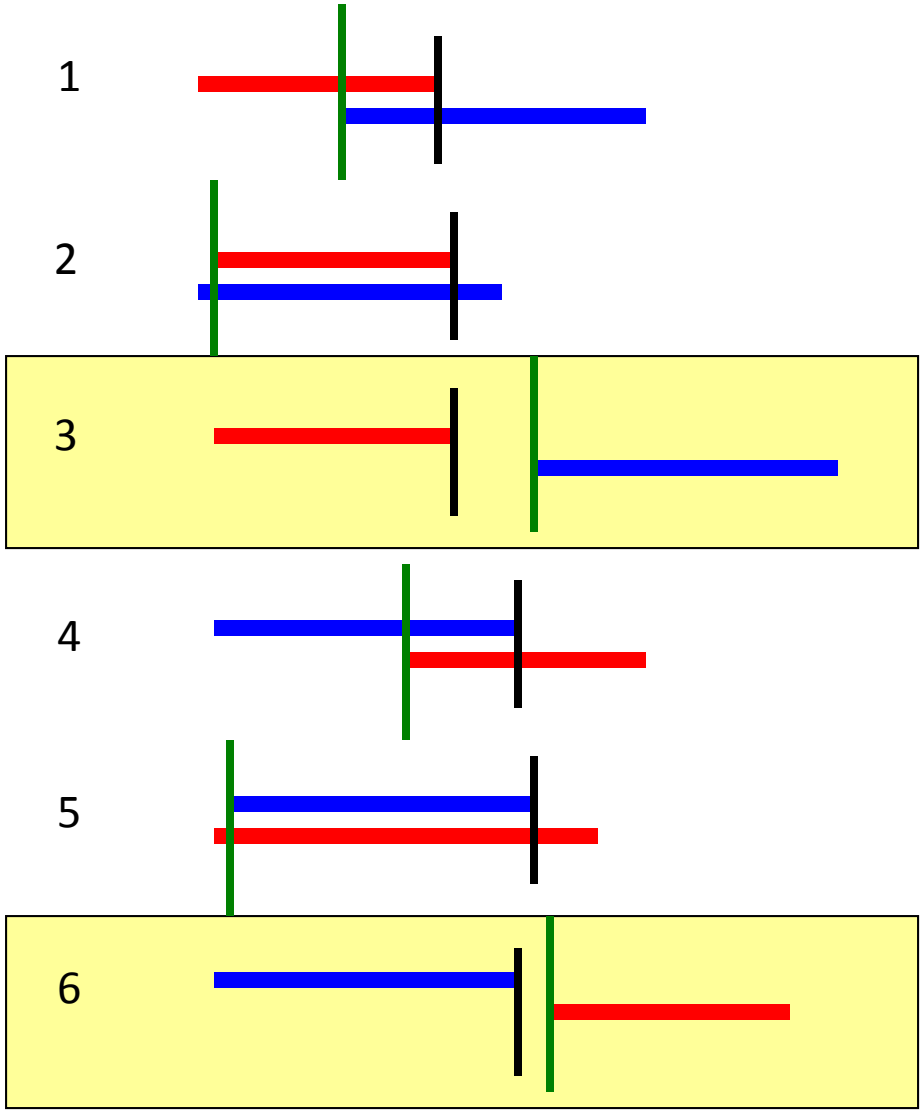


The overlap's left (OLeft) is the rightmost of the two original lefts



The overlap's left (OLeft) is the rightmost of the two original lefts

The overlap's right (ORight) is the leftmost of the two original rights



The overlap's left (OLeft) is the rightmost of the two original lefts

The overlap's right (ORight) is the leftmost of the two original rights

No overlap if OLeft > ORight

```
function Inter = overlap(self, other)
% Inter is overlapped Interval between self
% and the other Interval. If no overlap then
% self is empty Interval.

  Inter= Interval.empty();
  left= max(self.left, other.left);
  right= min(self.right, other.right);
  if right-left > 0
      Inter= Interval(left, right);
  end
end
```

Built-in function to create an empty object of the specified class

Built-in function isempty

```
% Example use of overlap function
A= Interval(3,7);
B= Interval(4,4+rand*5);
X= A.overlap(B);
if ~isempty(X)
    fprintf('(%f,%f)\n', X.left,X.right)
end
```

Overloading built-in functions

- You can change the behavior of a built-in function for an object of a class by implementing a function of the same name in the class definition
- Called "overloading"
- A typical built-in function to overload is **`disp`**
  - Specify which properties to display, and how, when the argument to **`disp`** is an object
  - Matlab calls **`disp`** when there's no semi-colon at the end of an assignment statement

See **`Interval.m`**