- Previous lecture:
  - Objects are passed by reference to functions
  - Details on class definition (constructor, instance method)
- Today's lecture:
  - More practice with instance methods
  - Overriding methods
  - Array of objects
  - Methods that handle variable numbers of arguments
- Announcements:
  - Prelim 2 tonight 7:30pm
    - CALS Auditorium in Kennedy Hall (Rm 116)
  - Lab exercise problem 2 to be submitted on CMS by Monday 11/14, at 11pm.

classdef syntax summary

A class file has the name of the class and 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 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

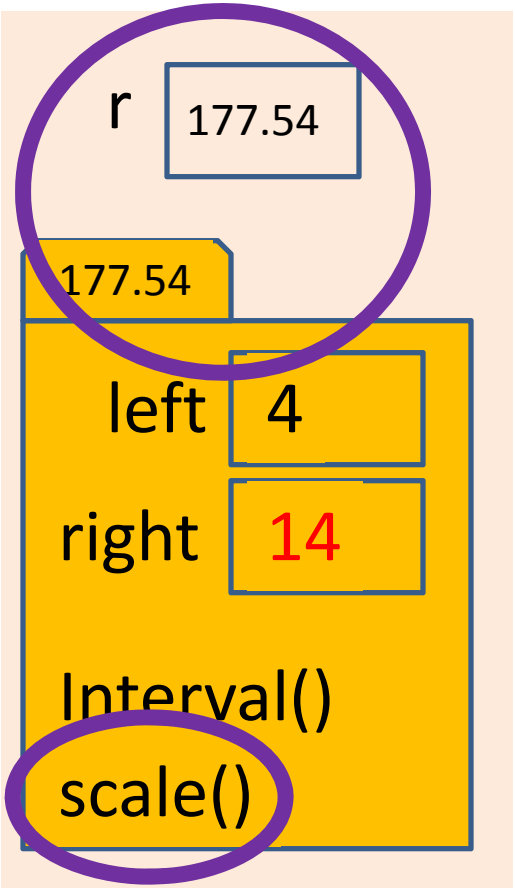
   methods
      function Inter = Interval(lt, rt)
      % Constructor:  construct an Interval obj
         Inter.left= lt;
         Inter.right= rt;
      end

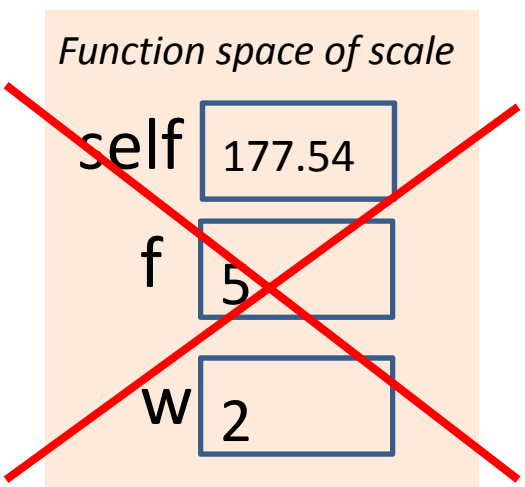
      function scale(self, f)
      % Scale the interval by a factor f
         w= self.right - self.left;
         self.right= self.left + w*f;
      end
   end
end
```

This file's name is Interval.m

Object is passed to a function by reference

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



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     right
   end

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      function Inter = Interval(lt, rt)
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         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
```

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 is deleted when the function ends.

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

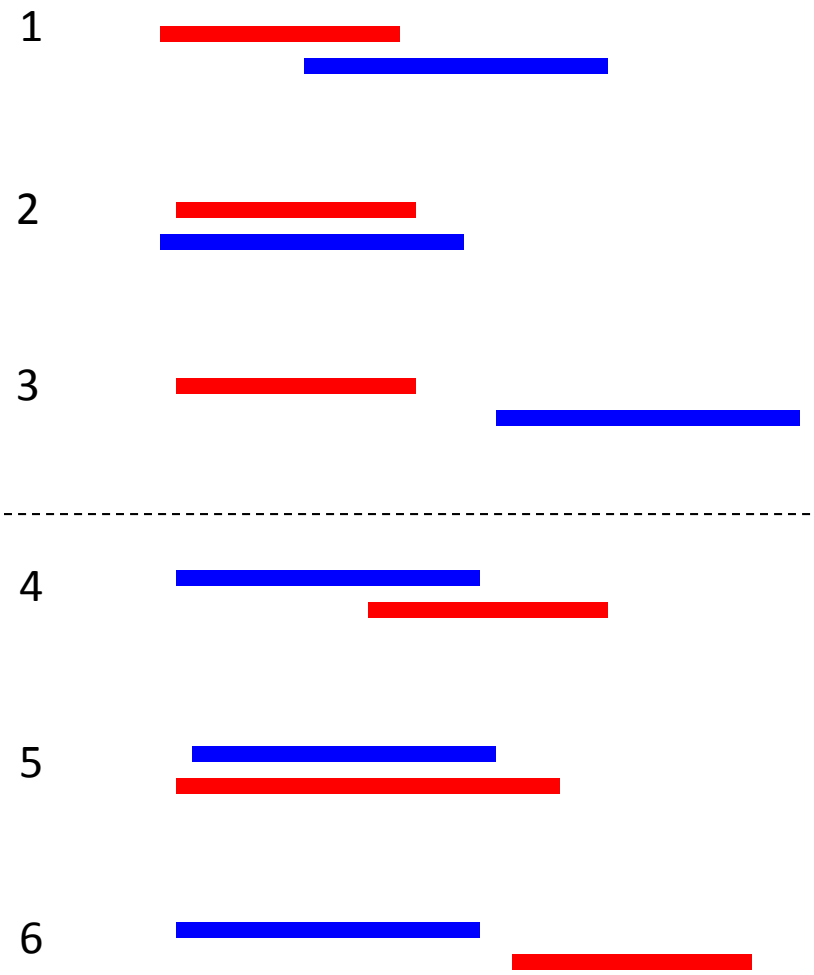
  function tf = isIn(self, other)
  % tf is true if self is in other interval
    tf= self.left>=other.left && ...
        self.right<=other.right;
  end


  end
end
```

Method to find overlap between two Intervals

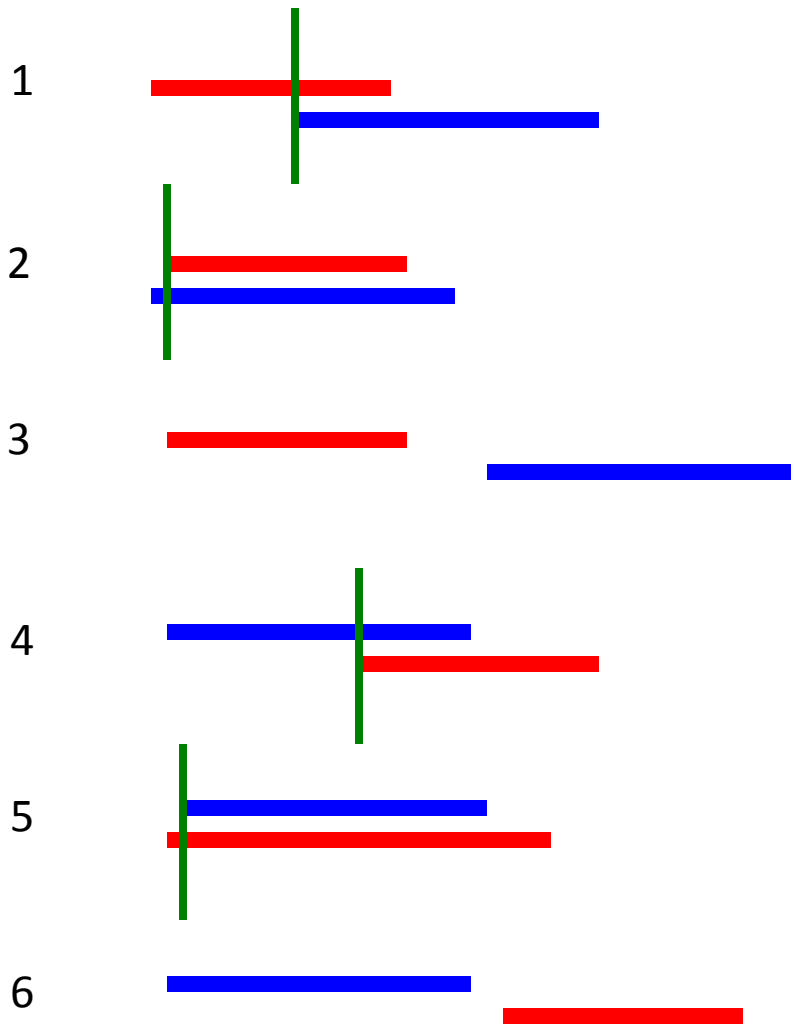
```
function Inter = overlap(self, other)
% Inter is overlapped Interval between self
% and the other Interval. If no overlap then
% self is empty Interval.
```

Compare two intervals

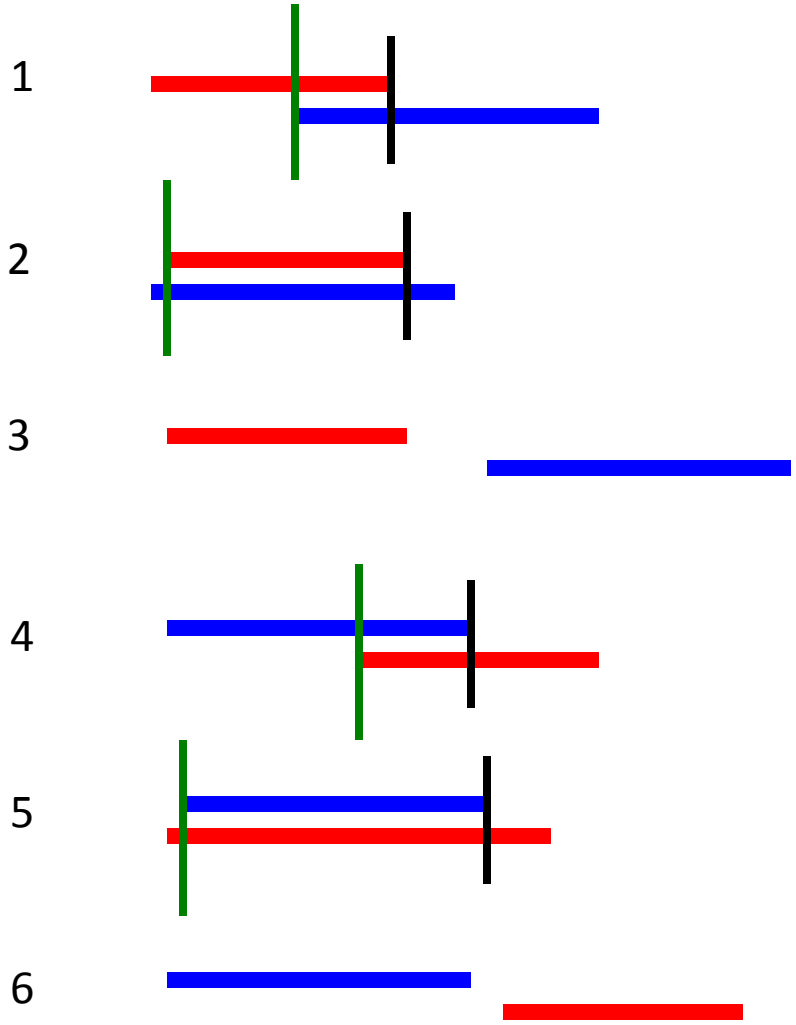


redRight < blueRight

blueRight < redRight

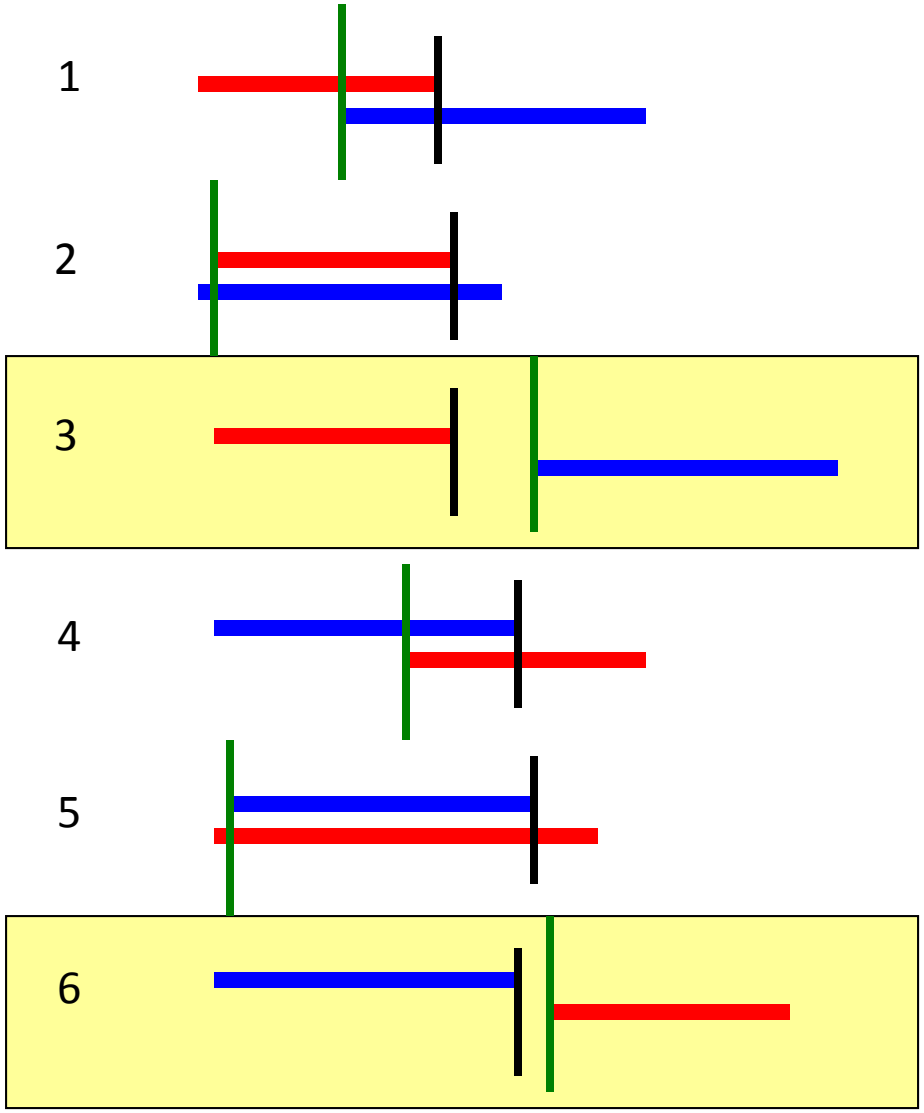


The overlap's left (OLeft) is the rightmost of the two original lefts



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 array 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
```

Overriding built-in functions

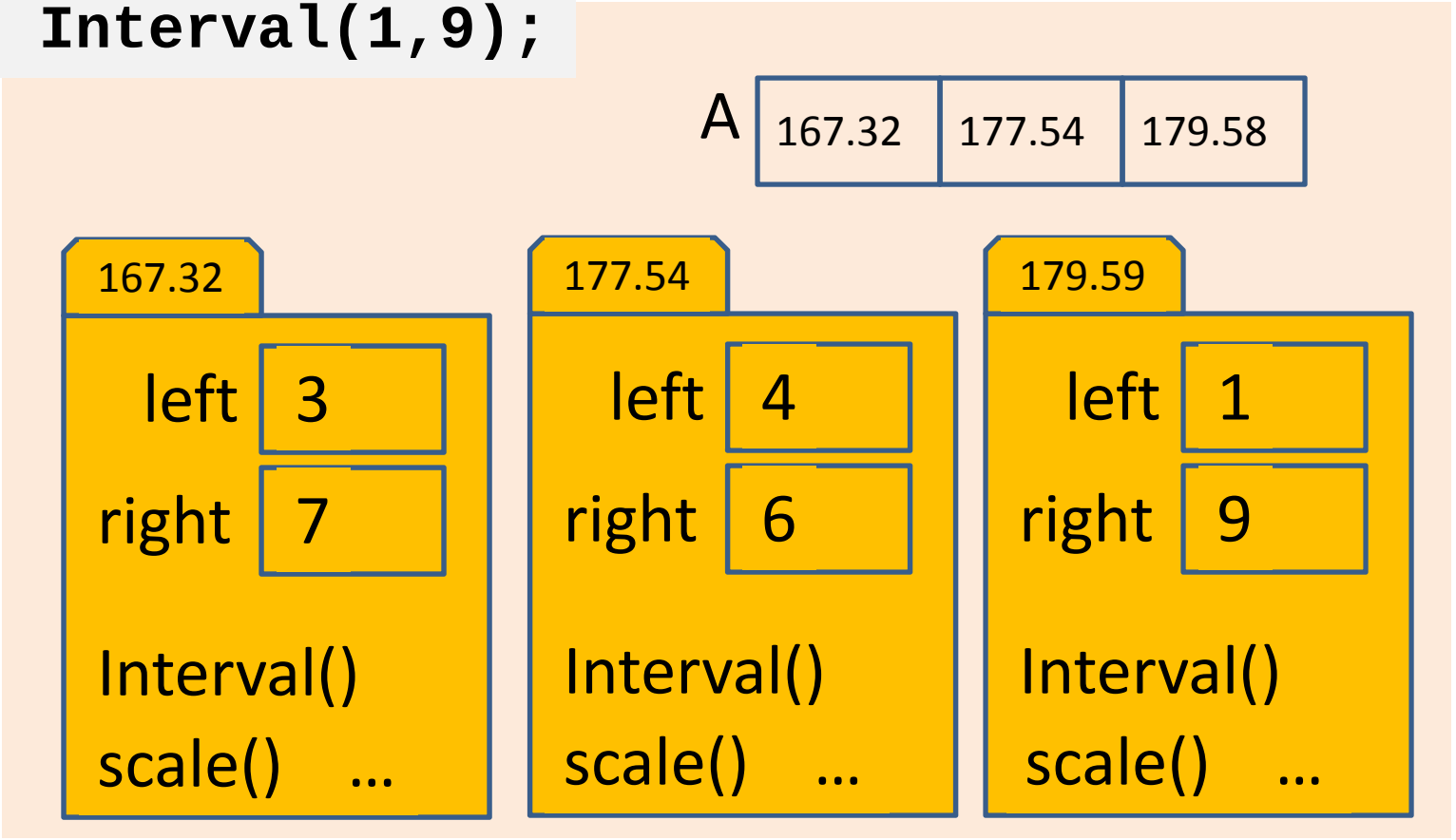
- You can change the behavior of a built-in function for an object of a class by implementing a function of the same name in the class definition
- Called "overriding" (called "overloading" in Matlab documentation)
- A typical built-in function to override is **`disp`**
  - Specify which properties to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

See **`Interval.m`**

An "array of objects" is really an …

array of references to objects

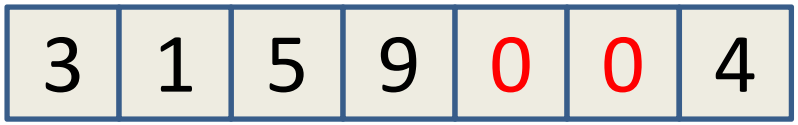
```
>> A= Interval(3,7);
>> A(2)= Interval(4,6);
>> A(3)= Interval(1,9);
```



MATLAB allows an array to be appended

```
v= [3 1 5 9]
v(7)= 4
```

- What happens to **`v(5)`** and **`v(6)`**?



- MATLAB assigns some "default value" to the skipped over components for simple, cell, and struct arrays
- For arrays of objects, you must implement the constructor to handle such a situation

Constructor needs to be able to handle a call with no arguments

```
>> A= Interval(3,7);     % Array of length 1
>> A(2)= Interval(4,6); % Array of length 2
>> A(3)= Interval(1,9); % Array of length 3
>> A(5)= Interval(2,5); % Array of length 5
```

Error!

- Interval constructor we have so far requires two parameters:

```
function Inter = Interval(lt, rt)
```

- User specified two arguments as required for A(5), but…
- Matlab has to assign A(4) "on its own" by calling the constructor, but no arguments get passed → Error!

Constructor that handles variable number of args

- When used inside a function, **`nargin`** returns the number of arguments that were passed

```
classdef  Interval < handle

  properties
    left
    right
  end

  methods
    function  Inter = Interval(lt, rt)

          Inter.left= lt;
          Inter.right= rt;

    end

    . . .

  end

end
```

Constructor that handles variable number of args

- When used inside a function, **`nargin`** returns the number of arguments that were passed
- If **`nargin`**≠2, constructor ends without executing the assignment statements. Then **`Inter.left`** and **`Inter.right`** get any default values defined under properties. In this case the default property values are **`[]`** (type **`double`**)

```
classdef  Interval < handle

  properties
    left
    right
  end

  methods
    function  Inter = Interval(lt, rt)
      if  nargin==2
          Inter.left= lt;
          Inter.right= rt;
      end
    end

    …

  end

end
```

If a class defines an object that may be used in an array…

- Constructor must be able handle a call that does not specify any arguments
  - Use built-in command **`nargin`**, which returns the number of function input arguments passed

- The overridden **`disp`** method, if implemented, should check for an input argument that is an array and handle that case explicitly. Details will be discussed next lecture.

A function to create an array of **`Interval`**s

```
function inters = intervalArray(n)
% Generate n random Intervals.  The left and
% right ends of each interval is in (0,1)

for k = 1:n
  randVals= rand(1,2);




end
```

An independent function, not an instance method. See **`intervalArray.m`**

A function to create an array of **Intervals**

```
function inters = intervalArray(n)
% Generate n random Intervals.  The left and
% right ends of each interval is in (0,1)

for k = 1:n
  randVals= rand(1,2);
  if randVals(1) > randVals(2)
     tmp= randVals(1);
     randVals(1)= randVals(2);
     randVals(2)= tmp;
  end
  inters(k)= Interval(randVals(1),randVals(2));
end
```

An independent function, not an instance method. See **intervalArray.m**

A function to find the widest Interval in an array

```
function inter = widestInterval(A)
% inter is the widest Interval (by width) in
% A, an array of Intervals
```

An independent function, not an instance method. See **`widestInterval.m`**

A function to find the widest Interval in an array

```
function inter = widestInterval(A)
% inter is the widest Interval (by width) in
% A, an array of Intervals

inter= A(1);  % widest Interval so far
for k= 2:length(A)
   if A(k).right – A(k).left > ...
                        inter.right – inter.left
       inter= A(k);
   end
end
```

An independent function, not an instance method. See **widestInterval.m**

A function to find the widest Interval in an array

```
function inter = widestInterval(A)
% inter is the widest Interval (by width) in
% A, an array of Intervals

inter= A(1);  % widest Interval so far
for k= 2:length(A)
   if A(k).getWidth() > inter.getWidth()
       inter= A(k);
   end
end
```

An independent function, not an instance method. See **widestInterval.m**