DATA 520
Lecture 19

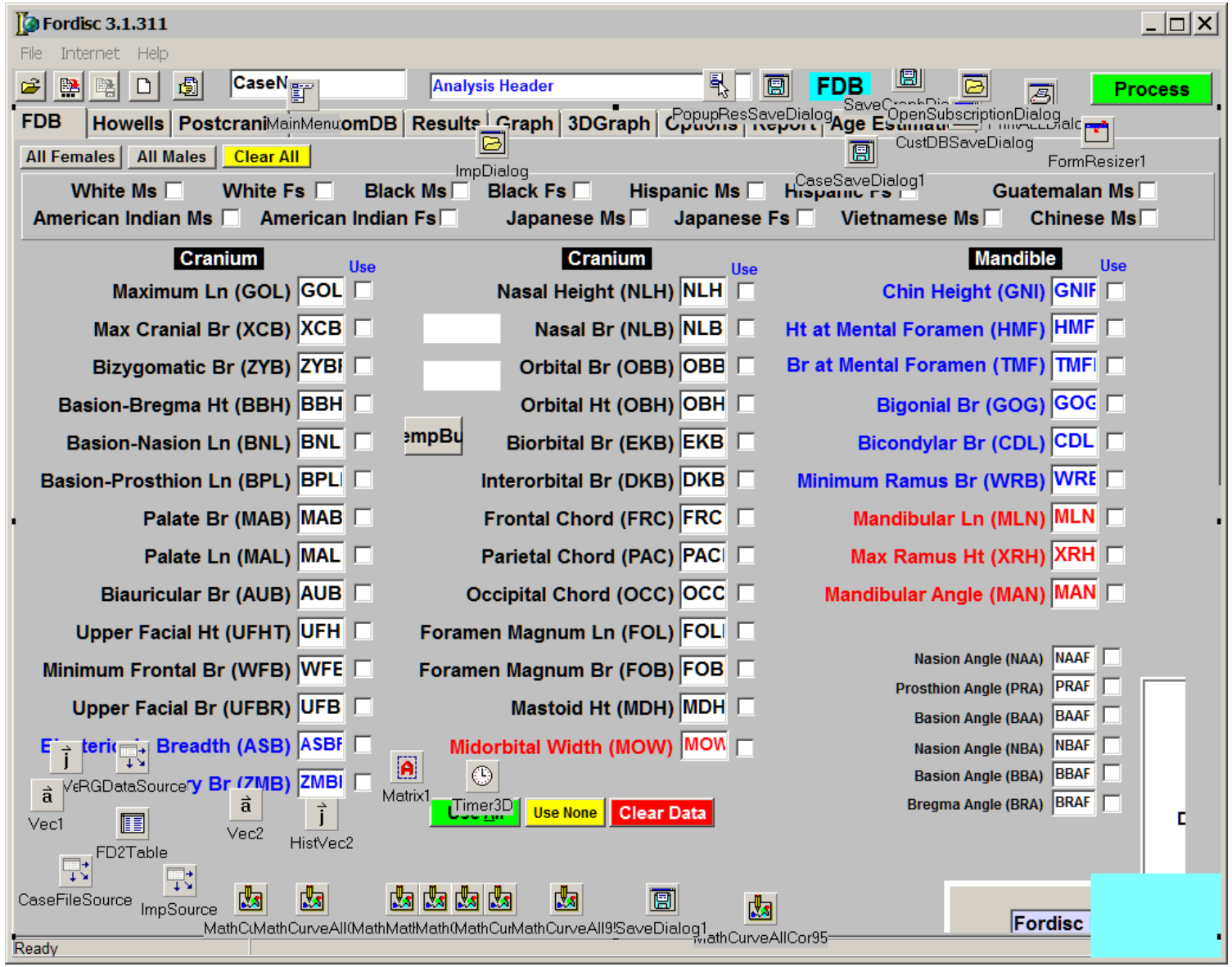
Search and Sort Algorithms II

Application Monday

Delphi 6:

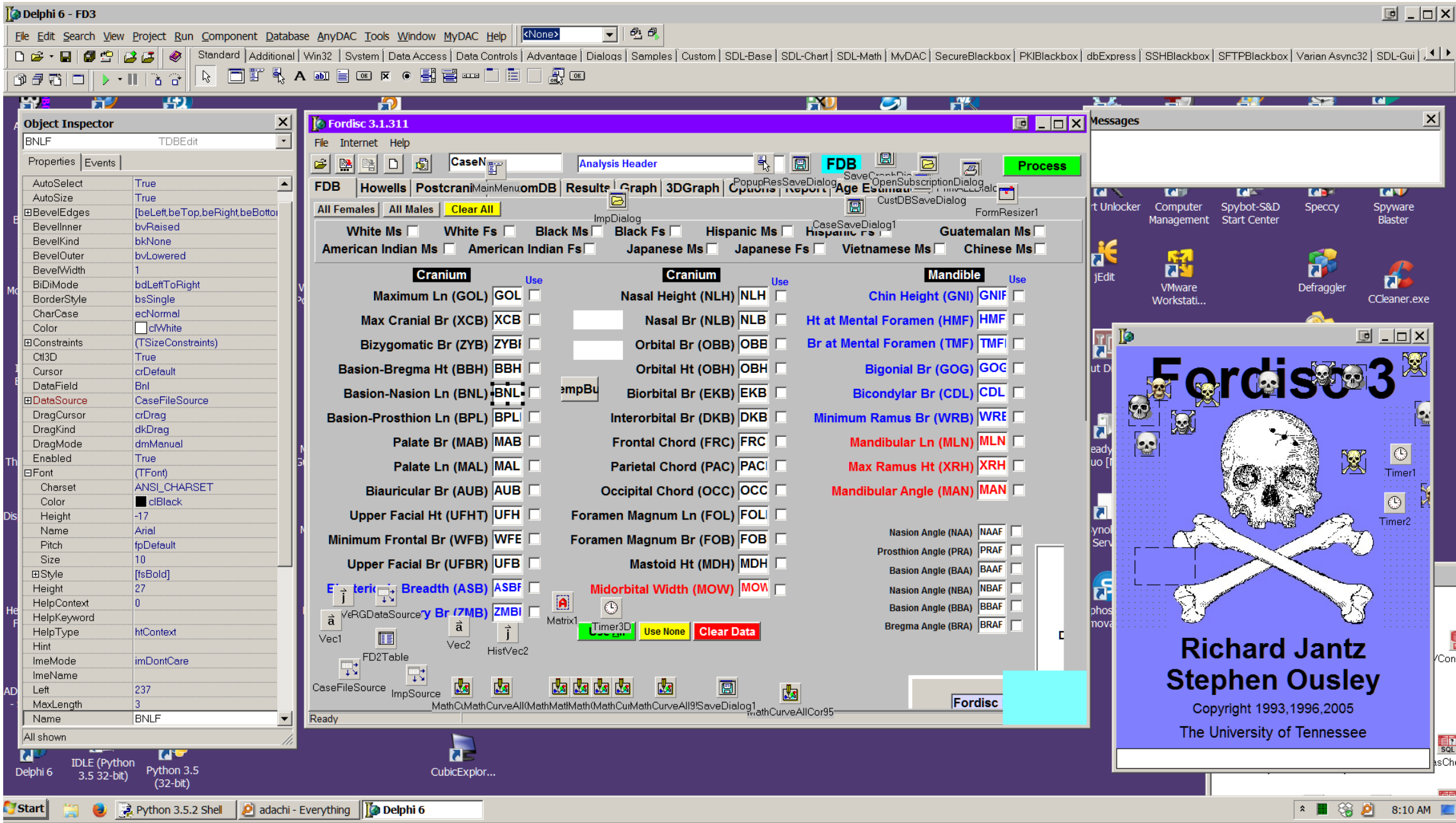
GUI and IDE

(Fordisc)



Delphi 6: GUI and IDE

Application Monday



Application Monday

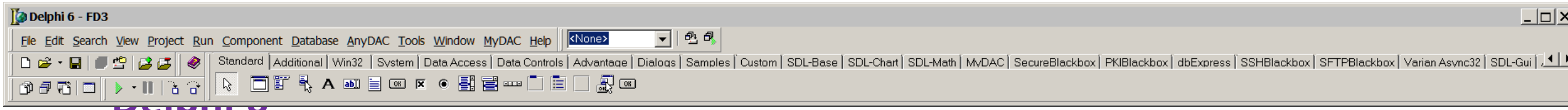
Delphi 6: Pascal

```
procedure TFD3Frm1.ChkForFsClick(Sender: TObject);
var i: integer;
begin
     DM1.casetable.edit;    //choose all females
    try
     For i := 0 to FD3Frm1.ComponentCount -1 do

      If (FD3Frm1.Components[i].tag = 4) and (FD3Frm1.Components[i] is TDBCheckbox)
      and (pos(' Fs',TDBCheckbox(FD3Frm1.Components[i]).caption) > 0)
    //  or (pos('Indian Fs',TDBCheckbox(FD3Frm1.Components[i]).caption) > 0)
        then
          begin

            DM1.casetable[TDBCheckbox(FD3Frm1.Components[i]).datafield] := 1; //True;
            TCheckbox(FD3Frm1.Components[i]).CHECKED := true;
          end;
    except
    end;

end;
```

code completion

4174: 52 | Insert | Code | Diagram

Application Monday

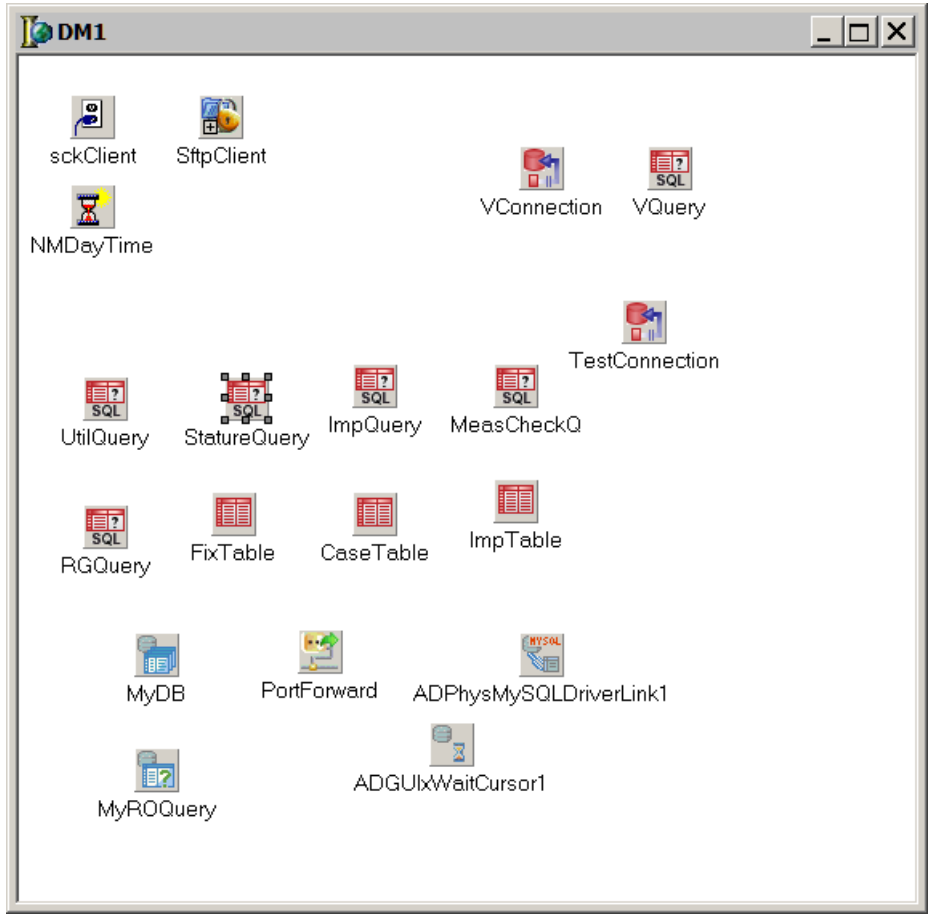


Delphi 6

Objects have properties and methods

```
object BNLF: TDBEdit
  Tag = 7
  Left = 237
  Top = 241
  Width = 41
  Height = 27
  Color = clWhite
  DataField = 'Bnl'
  DataSource = CaseFileSource
  Font.Charset = ANSI_CHARSET
  Font.Color = clBlack
  Font.Height = -17
  Font.Name = 'Arial'
  Font.Style = [fsBold]
  MaxLength = 3
  ParentFont = False
  TabOrder = 4
  OnChange = GOLFChange
  OnEnter = GOLFEnter
  OnExit = GOLFExit
  OnKeyPress = GOLFKeyPress
end
```

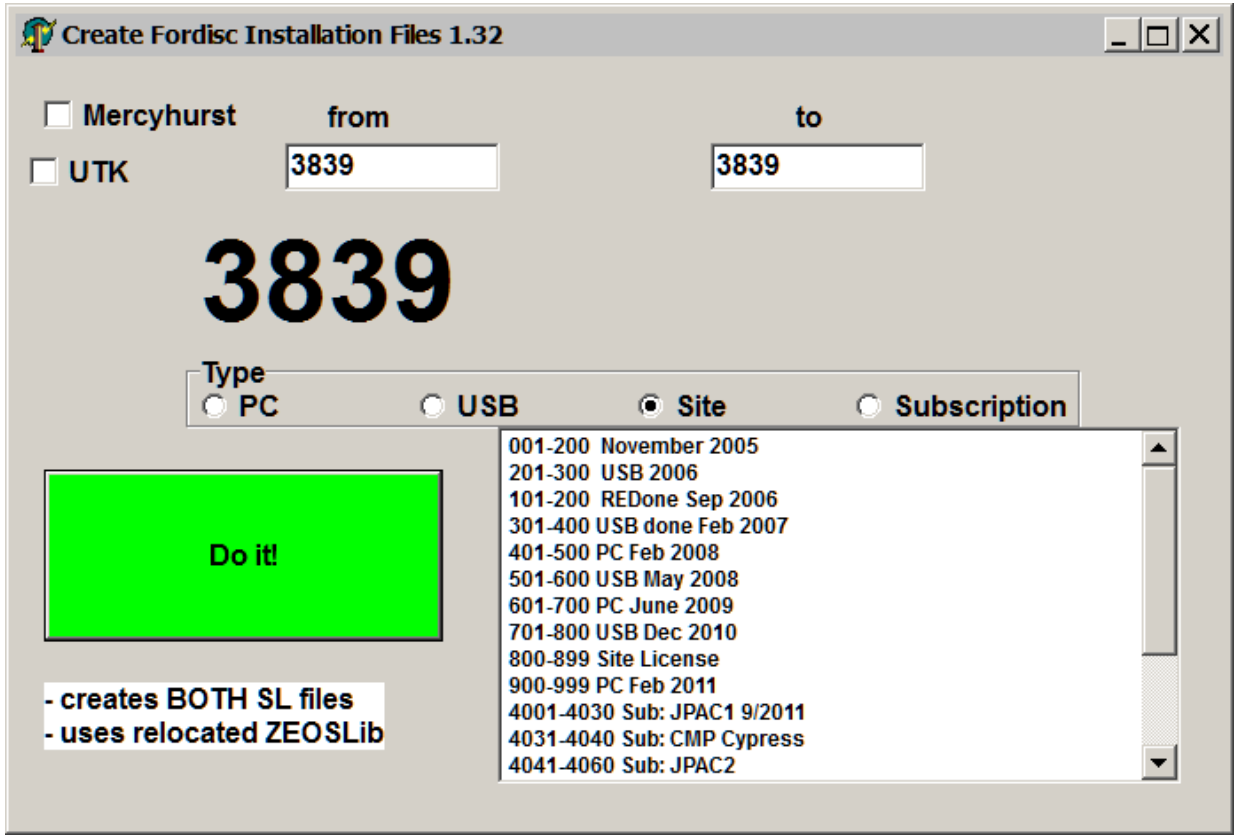
```
object MyDB: TADConnection
  Params.Strings = (
    'Compress=False'
    'Host=math.mercyhurst.edu'
    'AllowReconnect=True'
    'AutoCommit=False'
    'DriverID=MySQL')
  LoginPrompt = False
  BeforeConnect = MyDBBeforeConnect
  Left = 72
  Top = 360
end
```



Application Monday

Delphi 6: Create Fordisc installation files with serial numbers (DLL files):

- for PC, USB, Site License, Subscription (for secure labs)

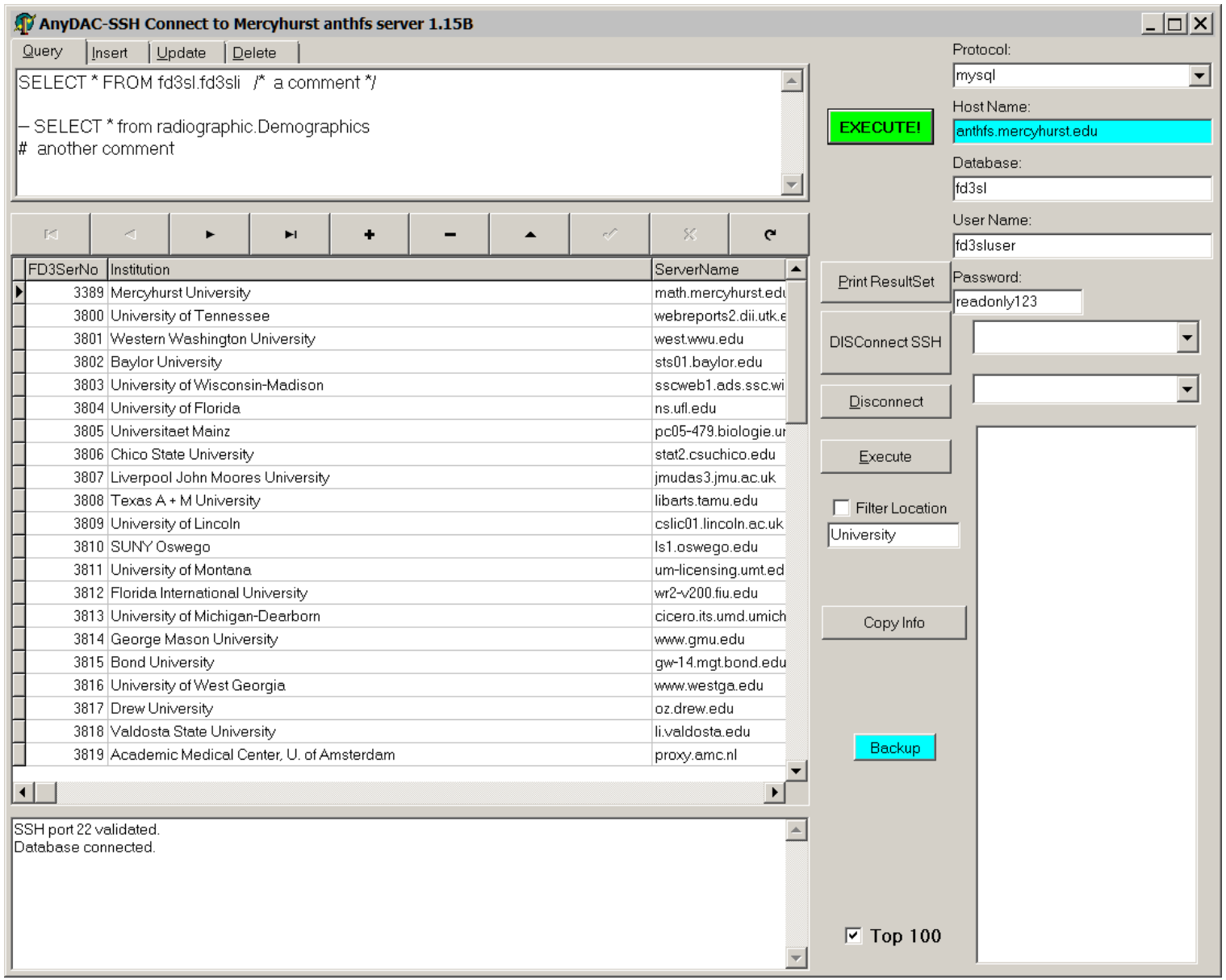


Application Monday

Delphi 6:

program to keep track of Fordisc subscription information

(MySQL)



Binary Search Times

Remember, these were on sorted lists

time_searches2.py output

```
Search times in a list of  10,000,001
Index     while           for           Sent          BinS      .index
10         0.00          0.00          0.00          0.01          0.00
5000000  897.03        349.20        472.75          0.01         68.98
9999951 1807.62        706.44        942.70          0.01        139.35
```

Sorting

What if we want to find the largest n or smallest n values in a list?

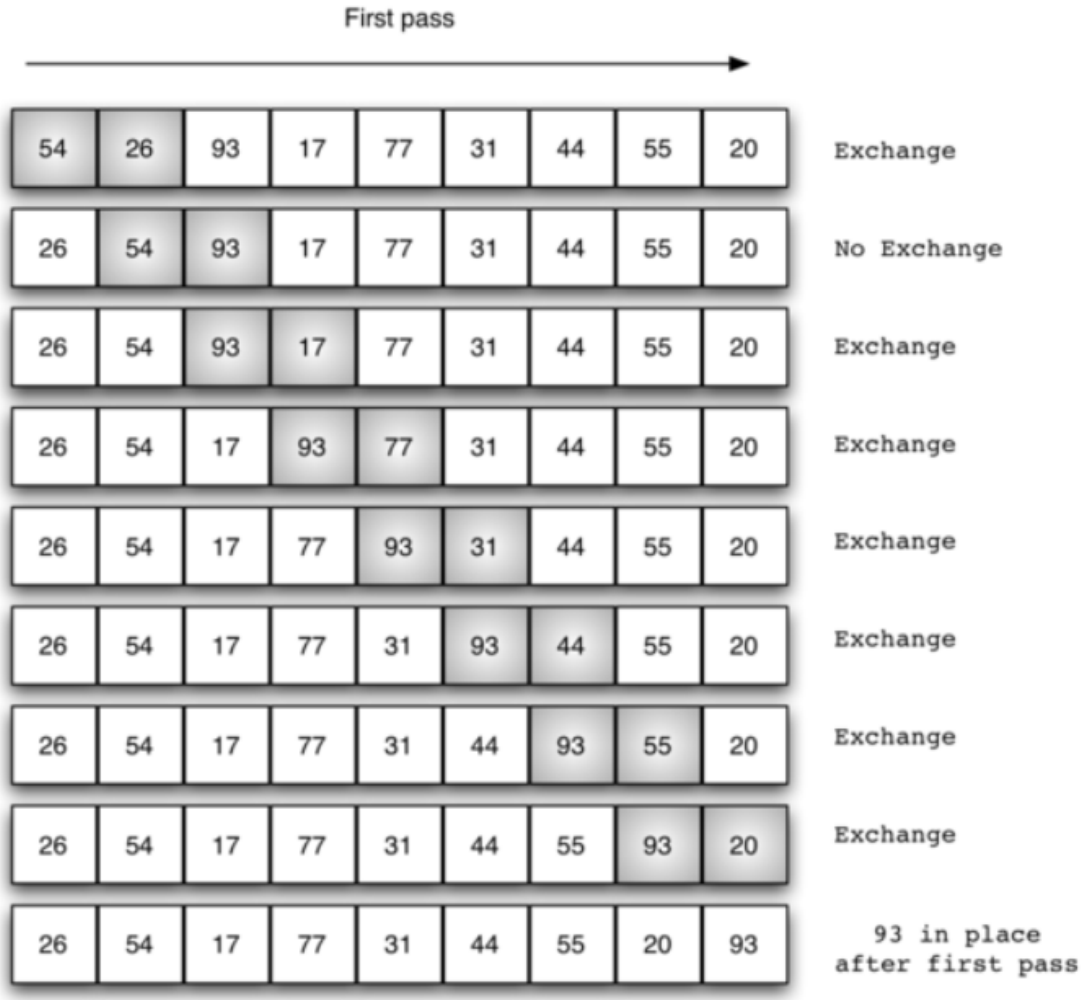
```
>>> CBA=[563,7590,1708,2142,3323,6197,1985,1316,1824,472,
1346,6029,2670,2094,2464,1009,1475,856,3027,4271,
3126,1115,2691,4253,1838,828,2403,742,1017,613,
3185,2599,2227,896,975,1358,264,1375,2016,452,
3292,538,1471,9313,864,470,2993,521,1144,2212,
2212,2331,2616,2445,1927,808,1963,898,2764,2073,
500,1740,8592,10856,2818,2284,1419,1328,1329,1479]

>>> scopy = sorted(CBA)

>>> scopy[-3:] # return largest 3

>>> scopy[0:3] # return smallest 3
```

But how does Python sort?

Bubble Sort

interactive sorting

https://interactivepython.org/runestone/static/pythonds/SortSearch/toctree.html



Bubble Sort

Must go through n times
- after first pass: largest value last (n-1 comparisons)
- after second, last 2 are the largest (n-2 comparisons)
- so we will need n-1 passes to get all in place and a lot of comparisons (n^2)

Big $O(n^2)$: how an algorithm scales to

On average, we trade places half of the time.

```
def bubbleSort(alist):
    for passnum in range(len(alist)-1,0,-1): # n times ; here: = range(8,0,-1)
        for i in range(passnum):  # n times
            if alist[i] > alist[i+1]:
                temp = alist[i]
                alist[i] = alist[i+1]
                alist[i+1] = temp

alist = [54,26,93,17,77,31,44,55,20]
bubbleSort(alist)
print(alist)
```

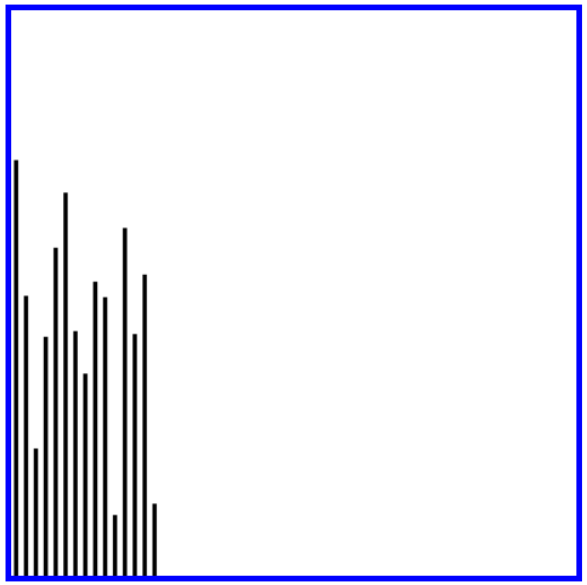
Bubble Sort

interactive sorting

https://interactivepython.org/runestone/static/pythonds/SortSearch/toctree.html

ActiveCode: 1 The Bubble Sort (lst_bubble)

The following animation shows `bubbleSort` in action.



Initialize | Run | Stop

Beginning | Step Forward | Step Backward | End

To analyze the bubble sort, we should note that regardless of how the items are arranged in the initial list, $n-1$ passes will be made to sort a list of size n. Table 1 shows the number of comparisons for each pass. The total number of comparisons is the sum of the first $n-1$ integers. Recall that the sum of the first n integers is $\frac{1}{2}n^2+\frac{1}{2}n$. The sum of the first $n-1$ integers is $\frac{1}{2}n^2+\frac{1}{2}n-n$, which is $\frac{1}{2}n^2-\frac{1}{2}n$. This is still $O(n^2)$ comparisons. In the best case, if the list is already ordered, no exchanges will be made. However, in the worst case, every comparison will cause an exchange. On average, we exchange half of the time.

Bubble Sort

If no exchanges, we know the list is sorted.

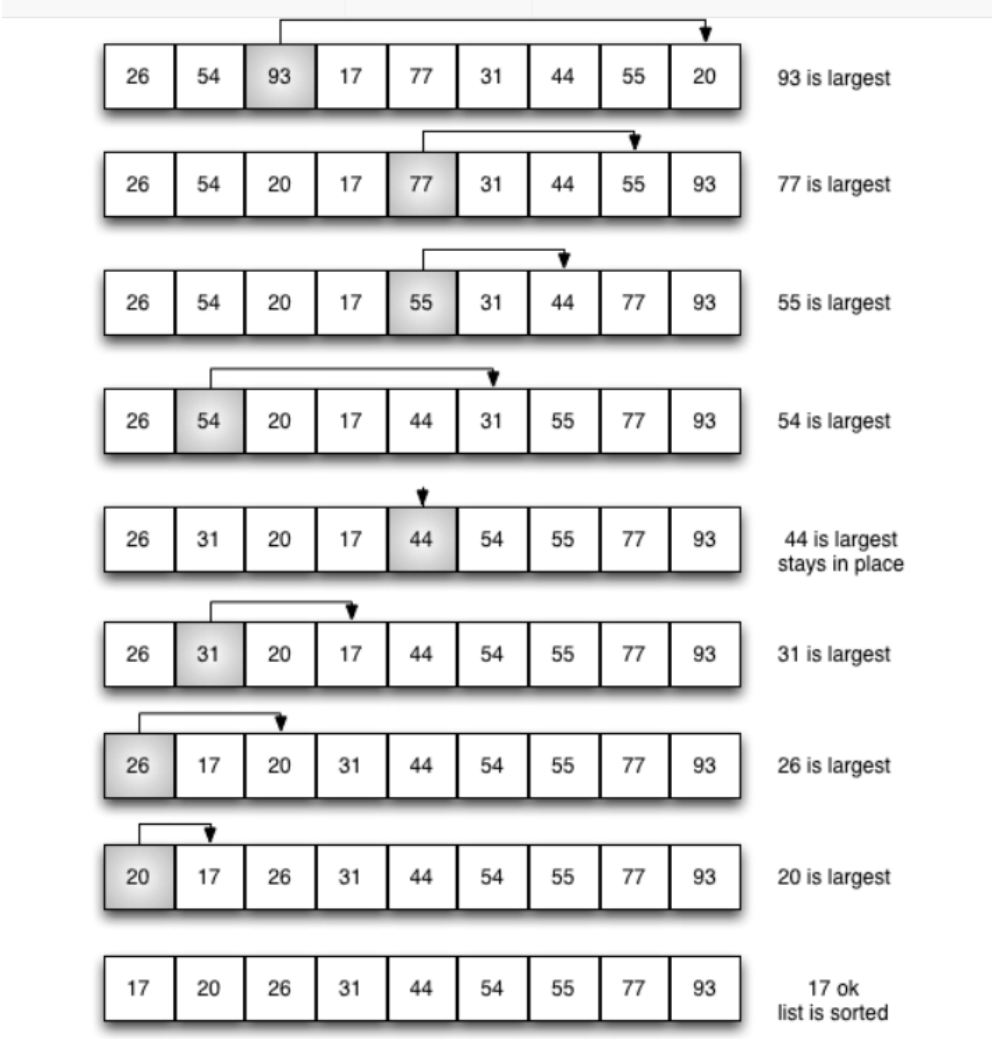
- will work quickly if only a few unsorted individuals
- so we can look for that happening

```
def shortBubbleSort(alist):
    exchanges = True
    passnum = len(alist)-1
    while passnum > 0 and exchanges:
       exchanges = False
       for i in range(passnum):
           if alist[i]>alist[i+1]:
               exchanges = True
               temp = alist[i]
               alist[i] = alist[i+1]
               alist[i+1] = temp
       passnum = passnum-1

alist=[20,30,40,90,50,60,70,80,100,110]
shortBubbleSort(alist)
print(alist)
```

Let's try some sorting using volunteers ...

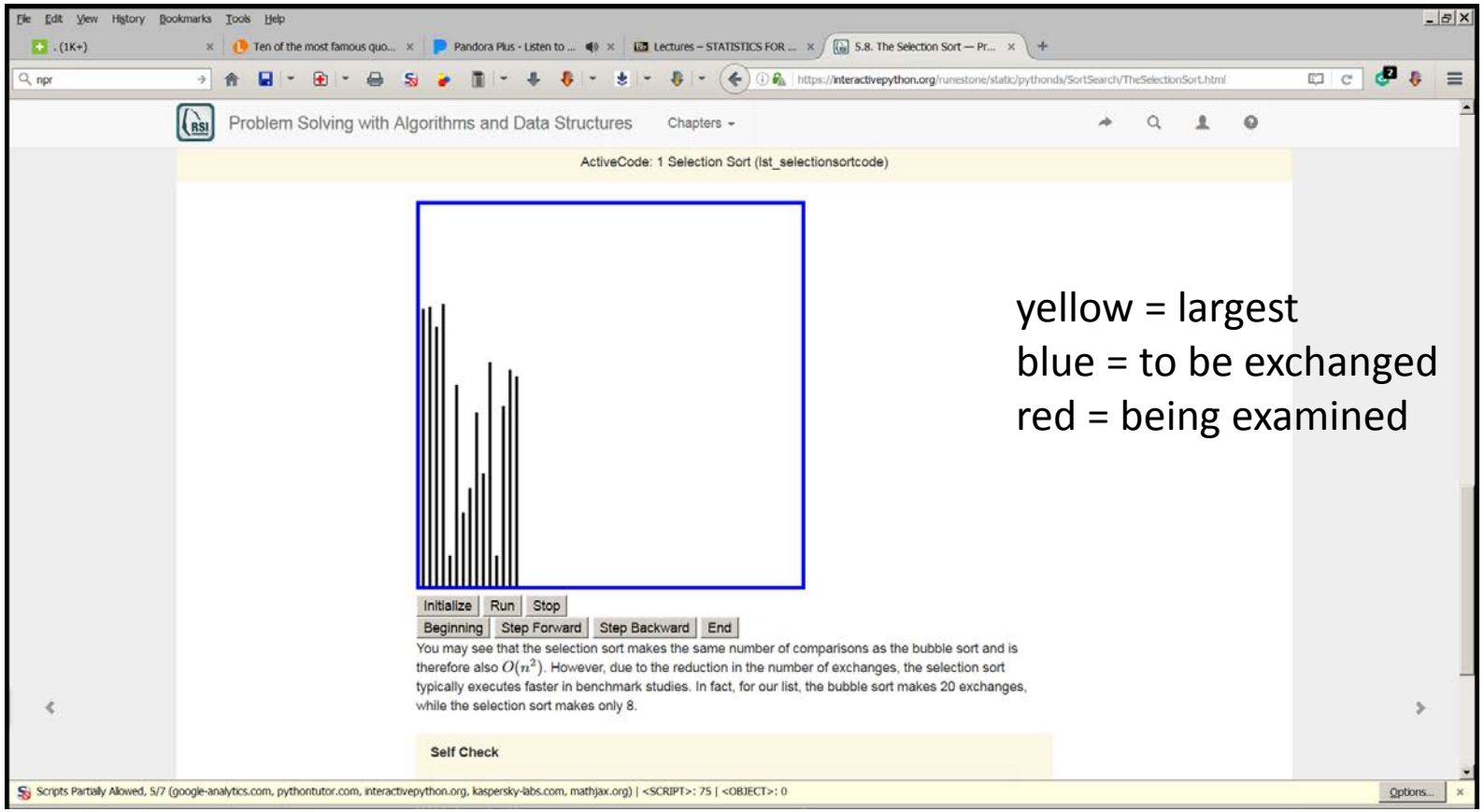
Selection Sort

Find the smallest item in the list and swap places with value in first position (0)
(or find the largest and swap with the last position)



Selection Sort

Find the smallest item in the list and swap places with value in first position (0)
(or find the largest and swap with the last position)
it does n^2 comparisons (looks at every one (n, n-1, n-2, etc.) to find the max)
- but it performs fewer exchanges than bubble sort



Selection Sort

Find the smallest item in the list and swap places with value in first position (0)
(or find the largest and swap with the last position)
Python has a special one-line method for swapping
(usually: `a,b;  temp = a;  a = b;  b = temp;`)

```
def selection_sort(L):
    i = 0
    while i != len(L):
        # Find the index of the smallest item in L[i:]
        # a fast way: L.index(min(L))
        # without using min(0 function:
        smallest = find_min(L, i)
        L[i], L[smallest] = L[smallest], L[i]
        i = i + 1

def find_min(L,b):
    smallest = b # The index of the smallest so far.
    i = b + 1
    while i != len(L):
        if L[i] < L[smallest]:
            # We found a smaller item at L[i].
            smallest = i

        i = i + 1

    return smallest
```

```
doctest:
    """ (list) -> NoneType
    Reorder the items in L from smallest to largest.
    >>> L = [3, 4, 7, -1, 2, 5]
    >>> selection_sort(L)
    >>> L
    [-1, 2, 3, 4, 5, 7]
    """
```

Selection Sort

Find the smallest item in the list and swap places with value in first position (0)

```
def selection_sort(L):  # we need expanded doctests
    """ (list) -> NoneType
    Reorder the items in L from smallest to largest.
    >>> L = [3, 4, 7, -1, 2, 5]
    >>> selection_sort(L)
    >>> L
    [-1, 2, 3, 4, 5, 7]
    >>> L = []
    >>> selection_sort(L)
    >>> L
    []
    >>> L = [1]
    >>> selection_sort(L)
    >>> L
    [1]
    >>> L = [2, 1]
    >>> selection_sort(L)
    >>> L
    [1, 2]
    >>> L = [1, 2]
    >>> selection_sort(L)
    >>> L
    [1, 2]
    >>> L = [3, 3, 3]
    >>> selection_sort(L)
    >>> L
    [3, 3, 3]
```

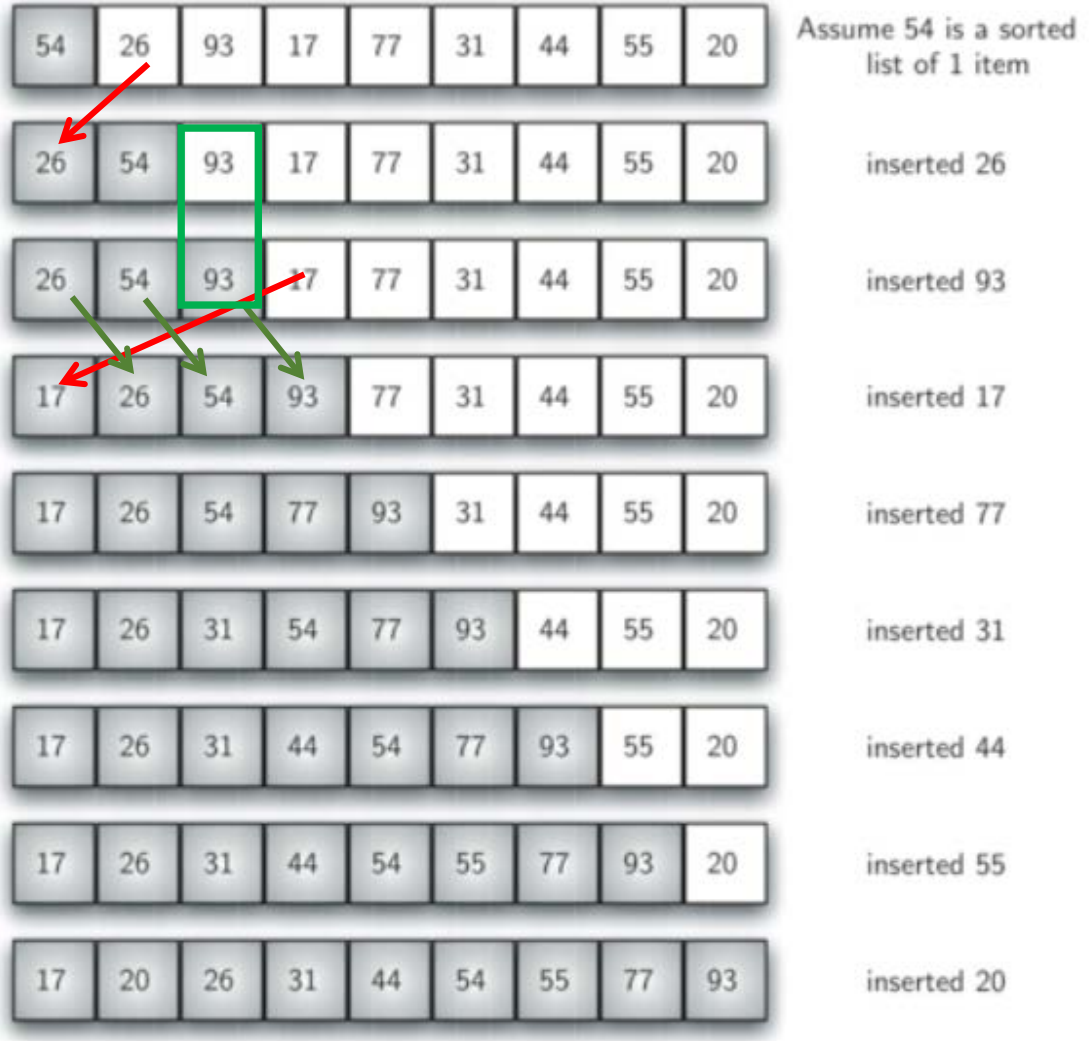
```
>>> L = [-5, 3, 0, 3, -6, 2, 1, 1]
    >>> selection_sort(L)
    >>> L
    [-6, -5, 0, 1, 1, 2, 3, 3]
    """
    i = 0
    while i != len(L):
        # Find the index of the smallest item in L[i:]
        # a fast way: L.index(min(L))
        # without using min(0 function:
        smallest = find_min(L, i)
        L[i], L[smallest] = L[smallest], L[i]
        i = i + 1

def find_min(L,b):
    smallest = b # The index of the smallest so far.
    i = b + 1
    while i != len(L):
        if L[i] < L[smallest]:
            # We found a smaller item at L[i].
            smallest = i

        i = i + 1

    return smallest


# doctest with verbose = True
if __name__ == '__main__':
    import doctest
    doctest.testmod(verbose=True)
```

Selection Sort

```
def selection_sort(L):
    """ (list) -> NoneType
    Reorder the items in L from smallest to largest.
    >>> L = [3, 4, 7, -1, 2, 5]
    >>> selection_sort(L)
    >>> L
    [-1, 2, 3, 4, 5, 7]
    >>> L = []
    >>> selection_sort(L)
    >>> L
    []
    >>> L = [1]
    >>> selection_sort(L)
    >>> L
    [1]
    >>> L = [2, 1]
    >>> selection_sort(L)
    >>> L
    [1, 2]
    >>> L = [1, 2]
    >>> selection_sort(L)
    >>> L
    [1, 2]
    >>> L = [3, 3, 3]
    >>> selection_sort(L)
    >>> L
    [3, 3, 3]
    >>> L = [-5, 3, 0, 3, -6, 2, 1, 1]
    >>> selection_sort(L)
    >>> L
    [-6, -5, 0, 1, 1, 2, 3, 3]
    """
    i = 0
    while i != len(L):
        # Find the index of the smallest item in L[i:]
        # a fast way: L.index(min(L))
        # without using min(0 function:
        smallest = find_min(L, i)
        L[i], L[smallest] = L[smallest], L[i]
        i = i + 1

def find_min(L,b):
    smallest = b # The index of the smallest so far.
    i = b + 1
    while i != len(L):
        if L[i] < L[smallest]:
            # We found a smaller item at L[i].
            smallest = i

        i = i + 1

    return smallest

# doctest with verbose = True
if __name__ == '__main__':
    import doctest
    doctest.testmod(verbose=True)
```

Insertion Sort

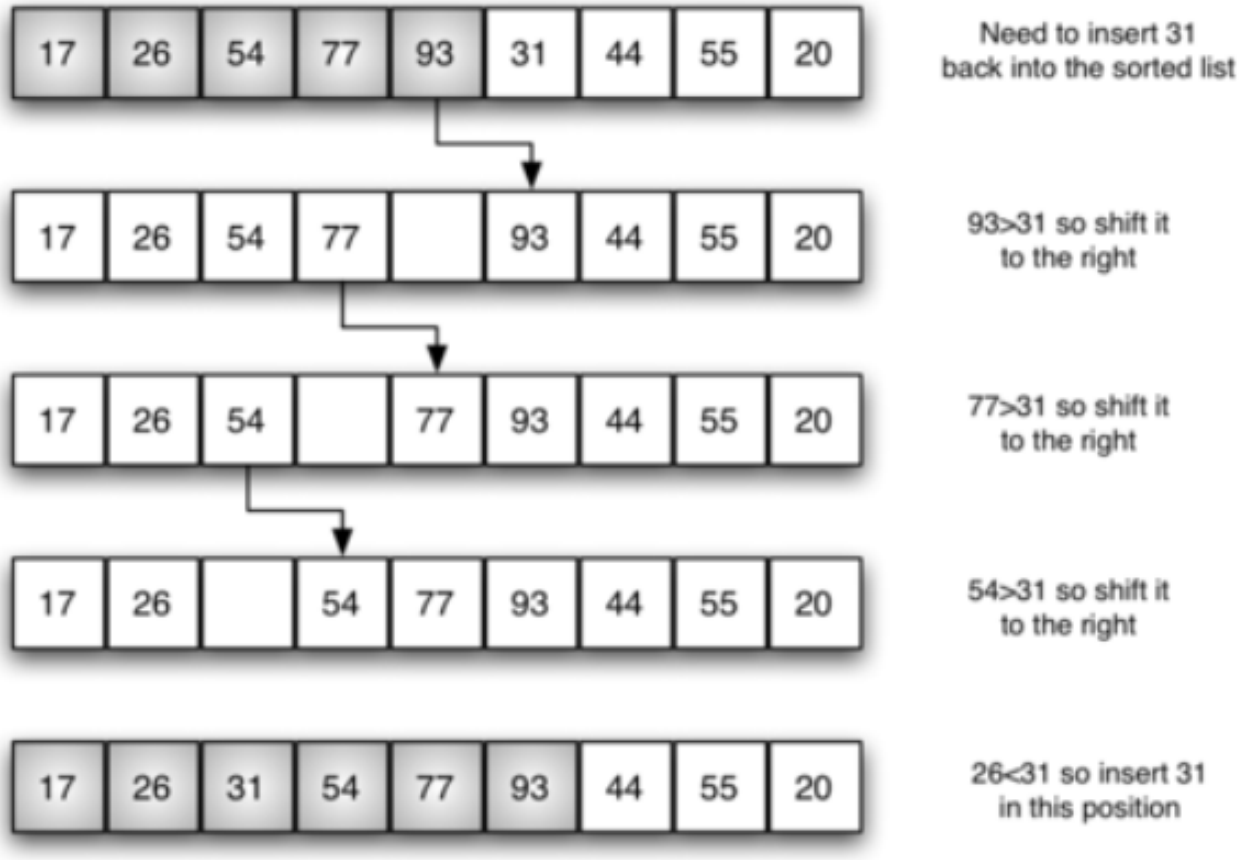
Go through every item, building a sorted list from the beginning



Insertion Sort

Go through every item, building a sorted list from the beginning
Fifth step: fewer moves/switches than selection sort

The first two do not need to be moved

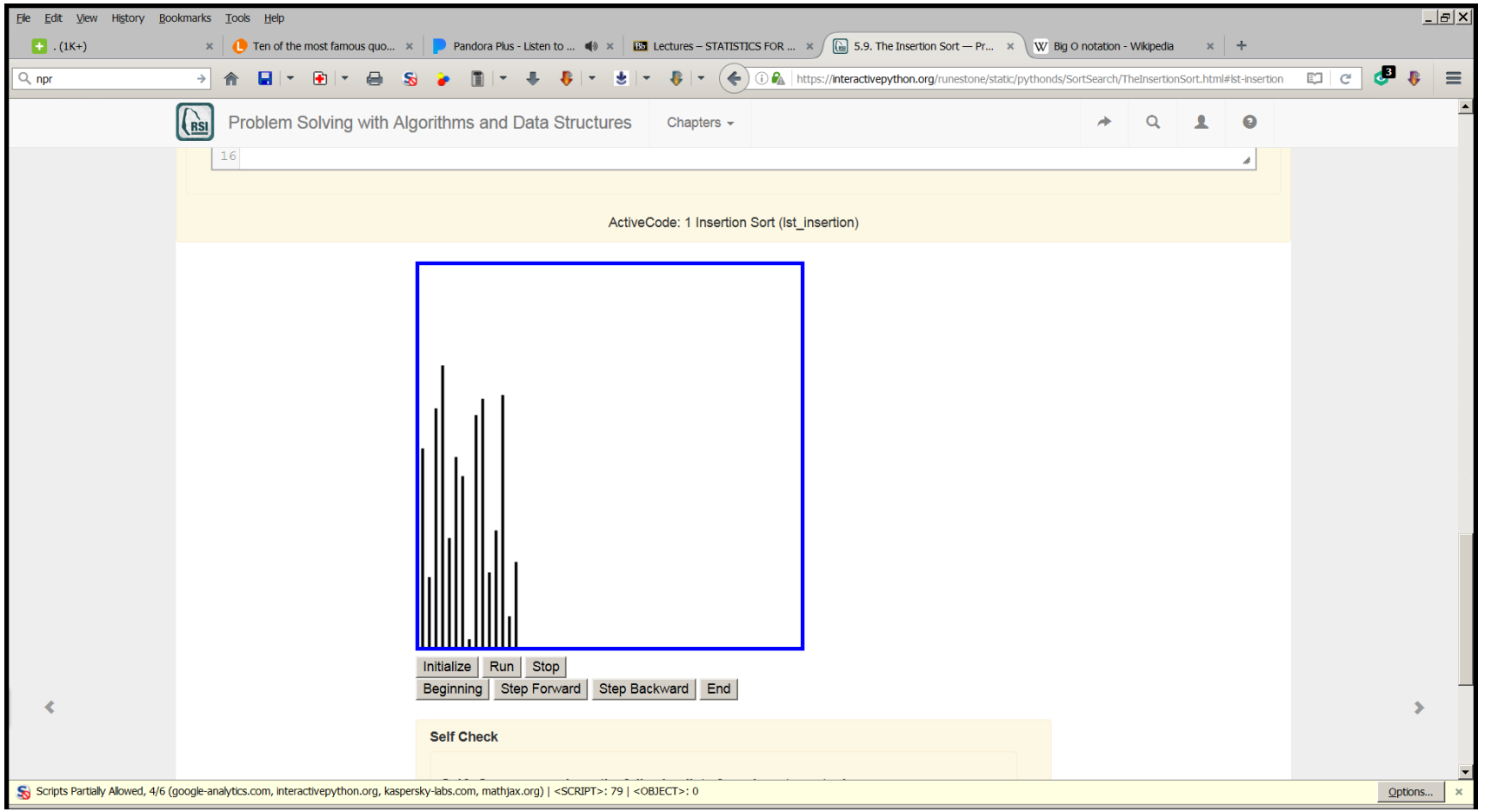


Insertion Sort

Go through every item, building a sorted list from the beginning

it does n^2 comparisons (looks at every one (n, n-1, n-2, etc.) to find the max)

- but it performs fewer exchanges than selection sort



Insertion Sort

```
# add to sort.py
def insert(L,b):
    """ (list, int) -> NoneType
    Precondition: L[0:b] is already sorted.
    Insert L[b] where it belongs in L[0:b + 1].
    [-1, 2, 3, 4, 7, 5]
    """
    # Find where to insert L[b] by searching backwards from L[b]
    # for a smaller item.
    i = b
    while i != 0 and L[i - 1] >= L[b]:
        i = i - 1

    # Move L[b] to index i, shifting the following values to the right.
    value = L[b]
    del L[b]
    L.insert(i, value)

def insertion_sort(L):
    i = 0
    while i != len(L):
        insert(L, i)
        i = i + 1
```

Insertion Sort

```
# add to sort.py
```

```
def insert(L,b):
    """ (list, int) -> NoneType
    Precondition: L[0:b] is already sorted.
    Insert L[b] where it belongs in L[0:b + 1].
    >>> L = [3, 4, -1, 7, 2, 5]
    >>> insert(L, 2)
    >>> L
    [-1, 3, 4, 7, 2, 5]
    >>> insert(L, 4)
    >>> L
    [-1, 2, 3, 4, 7, 5]
    """
    # Find where to insert L[b] by searching backwards from L[b]
    # for a smaller item.
    i = b
    while i != 0 and L[i - 1] >= L[b]:
        i = i - 1

    # Move L[b] to index i, shifting the following values to the right.
    value = L[b]
    del L[b]
    L.insert(i, value)

def insertion_sort(L):
    """ (list) -> NoneType
    Reorder the items in L from smallest to largest.
    >>> L = [3, 4, 7, -1, 2, 5]
    >>> insertion_sort(L)
    >>> L
    [-1, 2, 3, 4, 5, 7]
    >>> L = []
    >>> insertion_sort(L)
    >>> L
    []
    >>> L = [1]
    >>> insertion_sort(L)
    >>> L
    [1]
    >>> L = [2, 1]
    >>> insertion_sort(L)
    >>> L
    [1, 2]
    >>> L = [1, 2]
    >>> insertion_sort(L)
    >>> L
    [1, 2]
    >>> L = [3, 3, 3]
    >>> insertion_sort(L)
    >>> L
    [3, 3, 3]
    >>> L = [-5, 3, 0, 3, -6, 2, 1, 1]
    >>> insertion_sort(L)
    >>> L
    [-6, -5, 0, 1, 1, 2, 3, 3]
    """
    i = 0
    while i != len(L):
        insert(L, i)
        i = i + 1


# doctest with verbose = True
if __name__ == '__main__':
    import doctest
    doctest.testmod(verbose=True)
```

Binary Sort

Phonebook - should be N ($\log_2$ N) $\log_2$ N = N_2? (N base 2))
N values have to be inserted, so actually N(N + N_2) ~ N^2
add to sort.py

Mergesort

Along with quicksort and heapsort, divide and conquer algorithms
merge sorted lists, should be N $\log_2$ N
Compare a pair of sorted lists and add to another after comparing values
(Compare lists: L1 and L2)

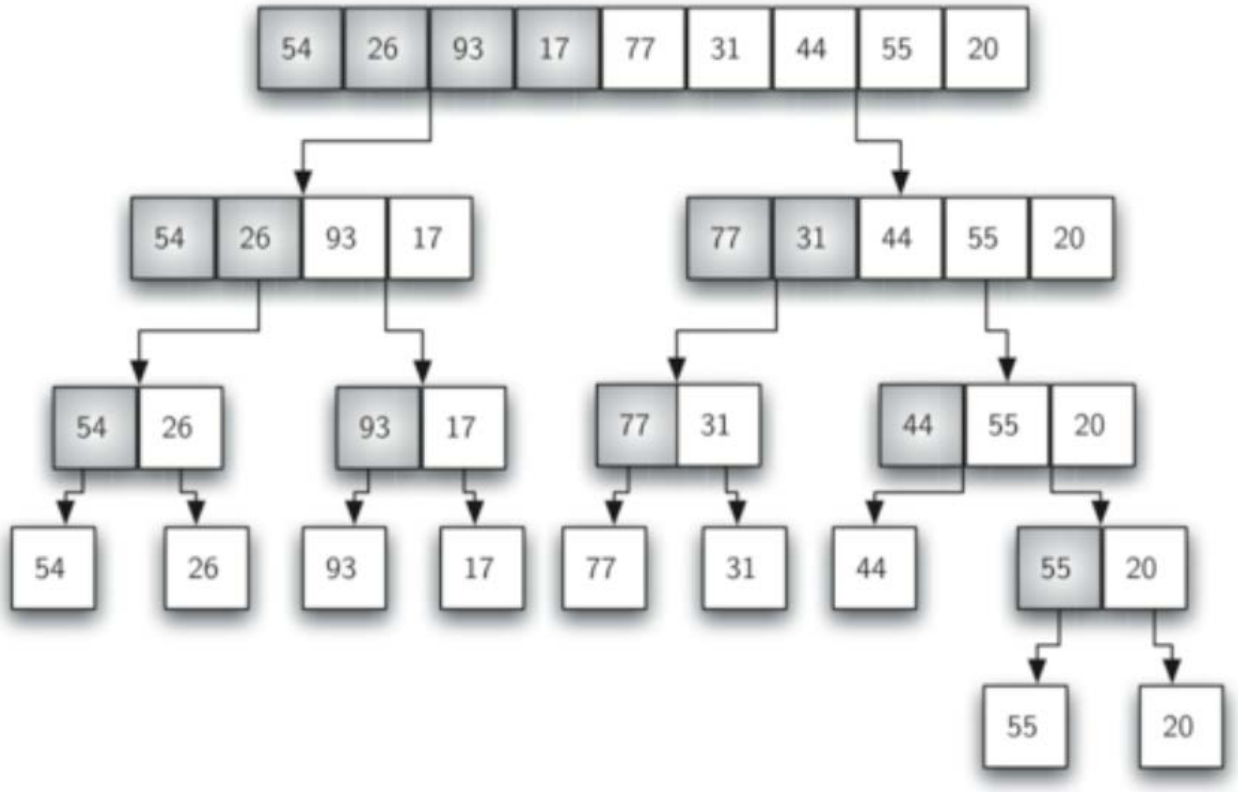
```
Merge sorted lists L1 and L2 into a new list and return that new list.

>>> merge([1, 3, 4, 6], [1, 2, 5, 7])

[1, 1, 2, 3, 4, 5, 6, 7]
```

Mergesort

Along with quicksort and heapsort, divide and conquer algorithms merge sorted lists recursively, should be N $\log_2$ N

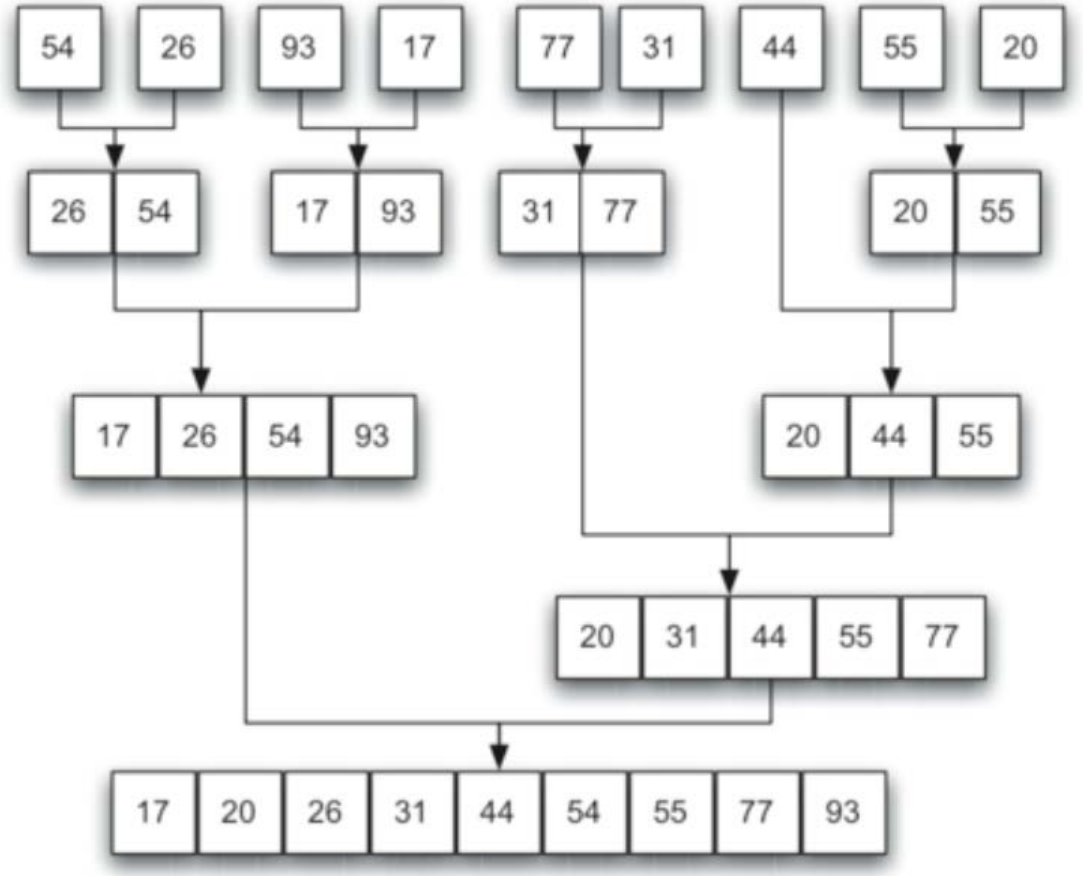
Compare a pair of sorted lists and add to another after comparing values (L1 or L2)

Divide first



Mergesort

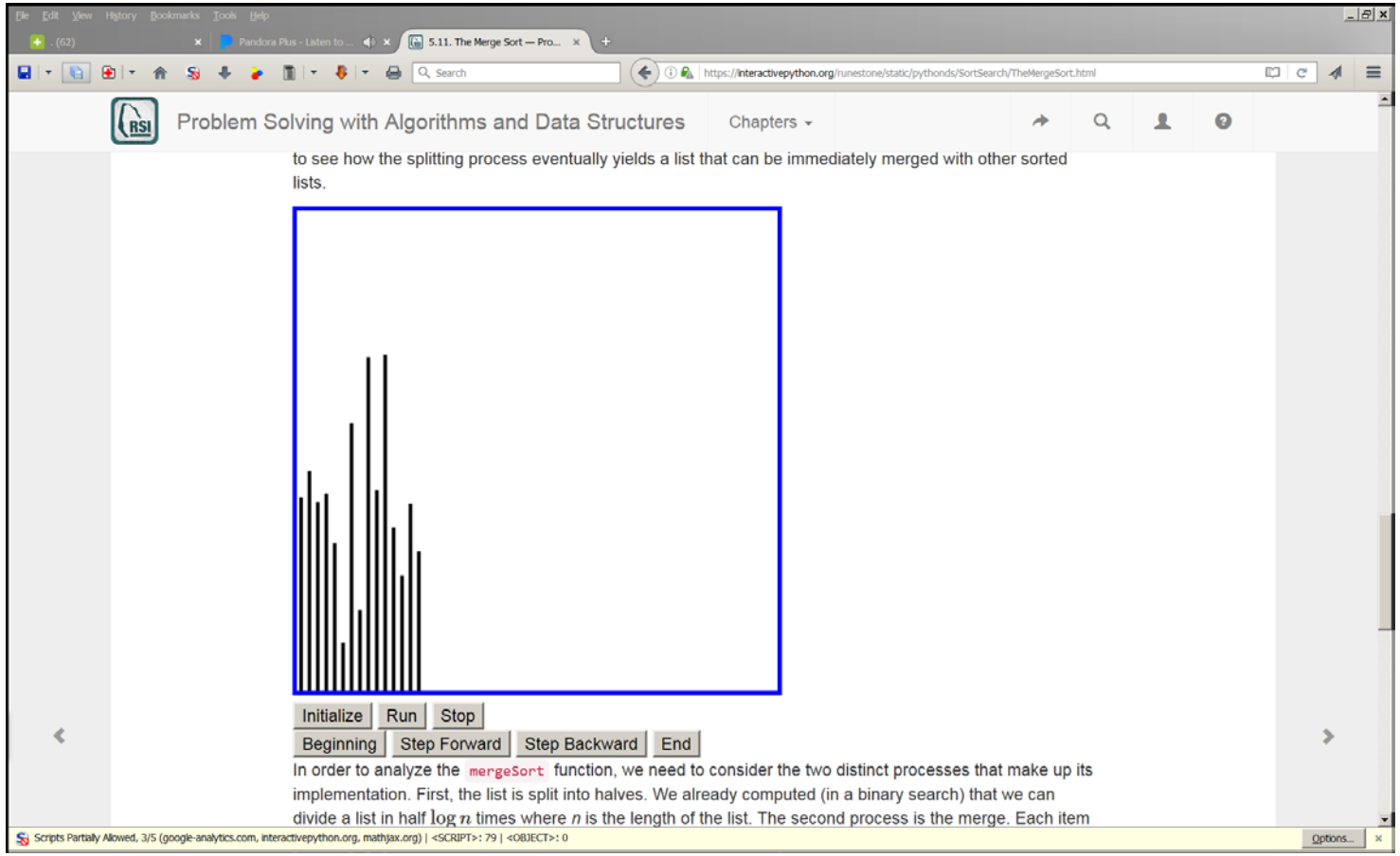
Along with quicksort and heapsort, divide and conquer algorithms
merge sorted lists, should be N $\log_2$ N
Compare a pair of sorted lists and add to another after comparing values (L1, L2)
Then merge



Mergesort

Along with quicksort and heapsort, divide and conquer algorithms merge sorted lists, should be N $\log_2$ N

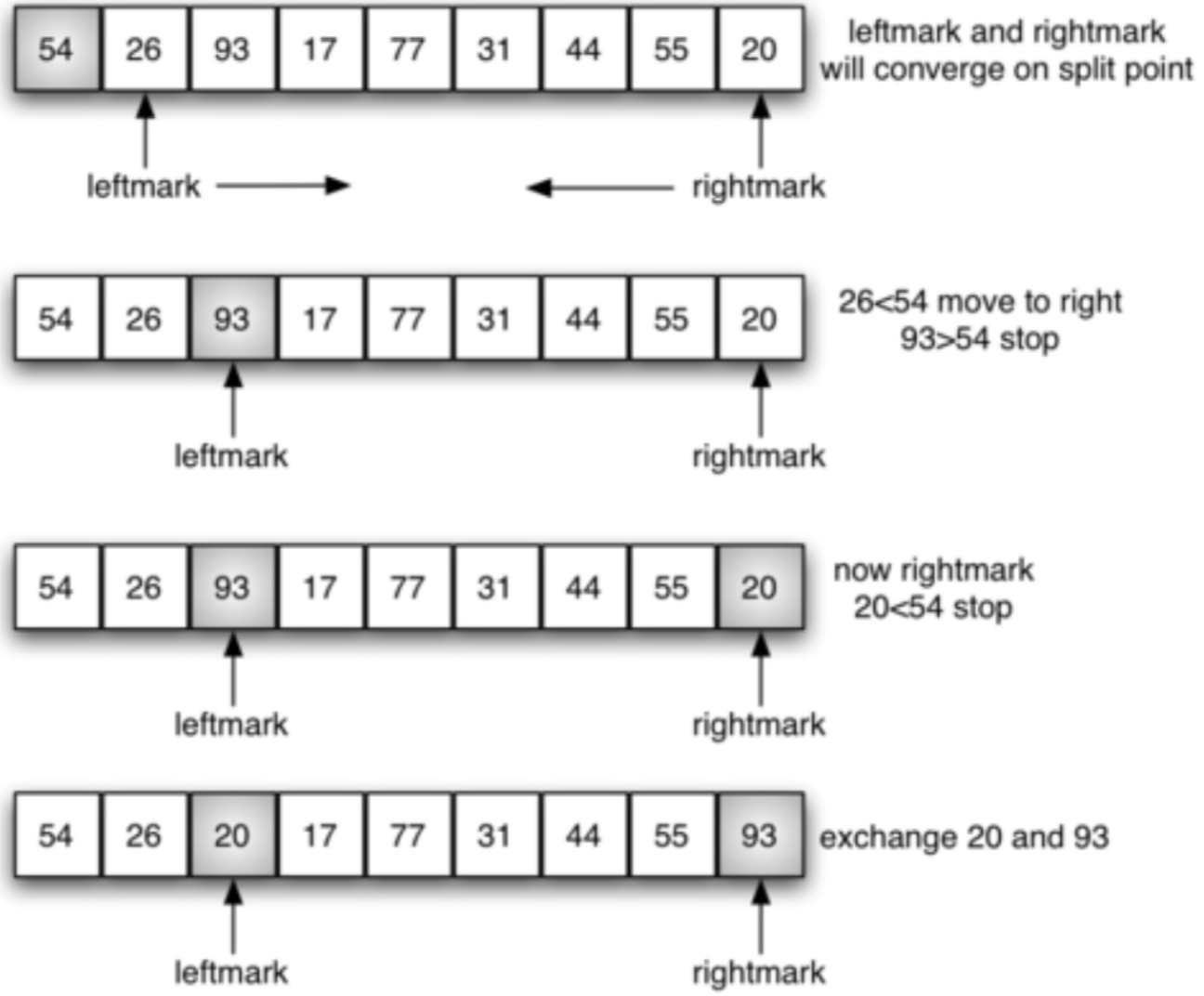
Compare a pair of sorted lists and add to another after comparing values (L1 or L2)



Quicksort

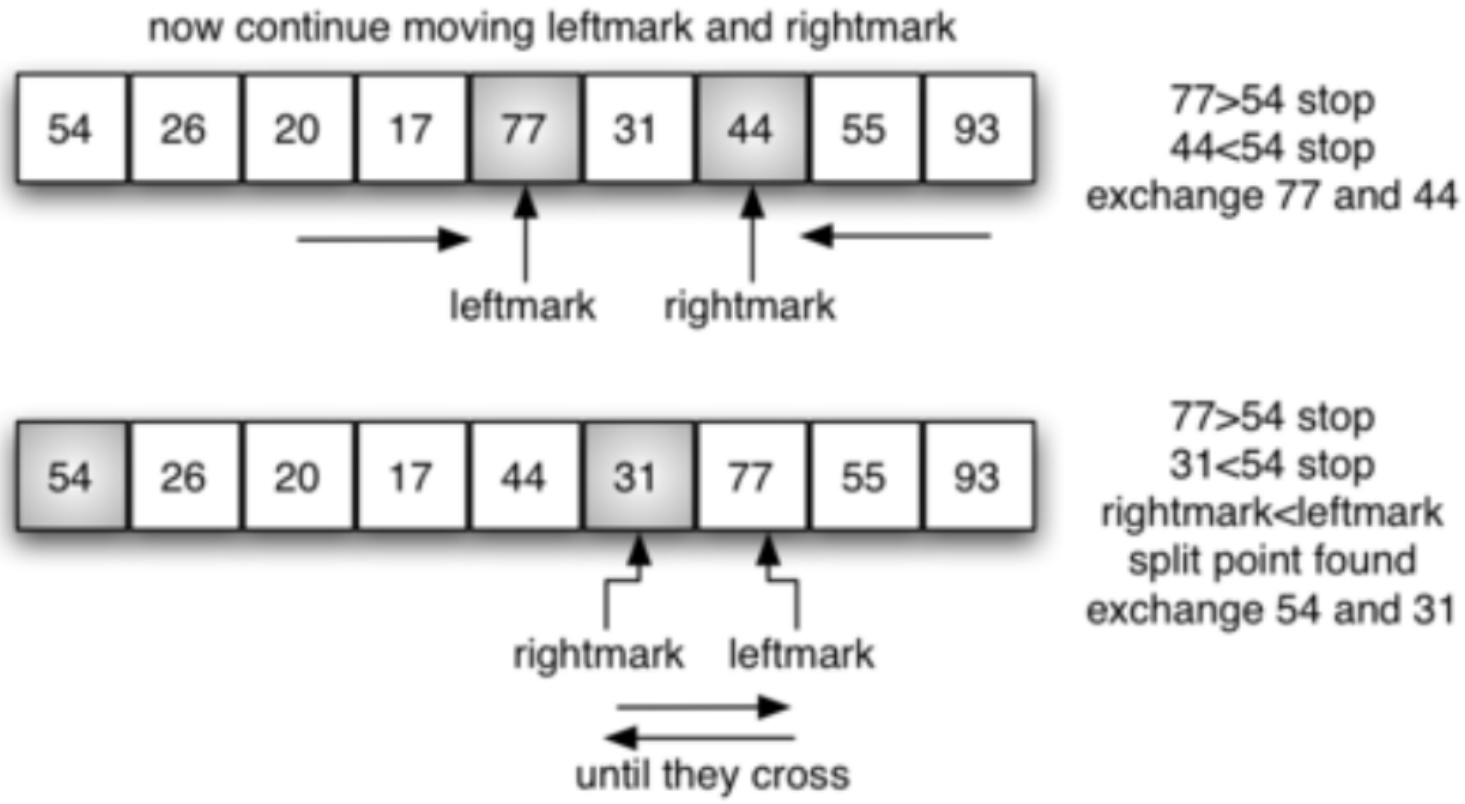
Along with mergesort and heapsort, a divide and conquer algorithm

Merge sorted lists, should be N $\log_2$ N
Exchange positions within a list based on a "pivot value"



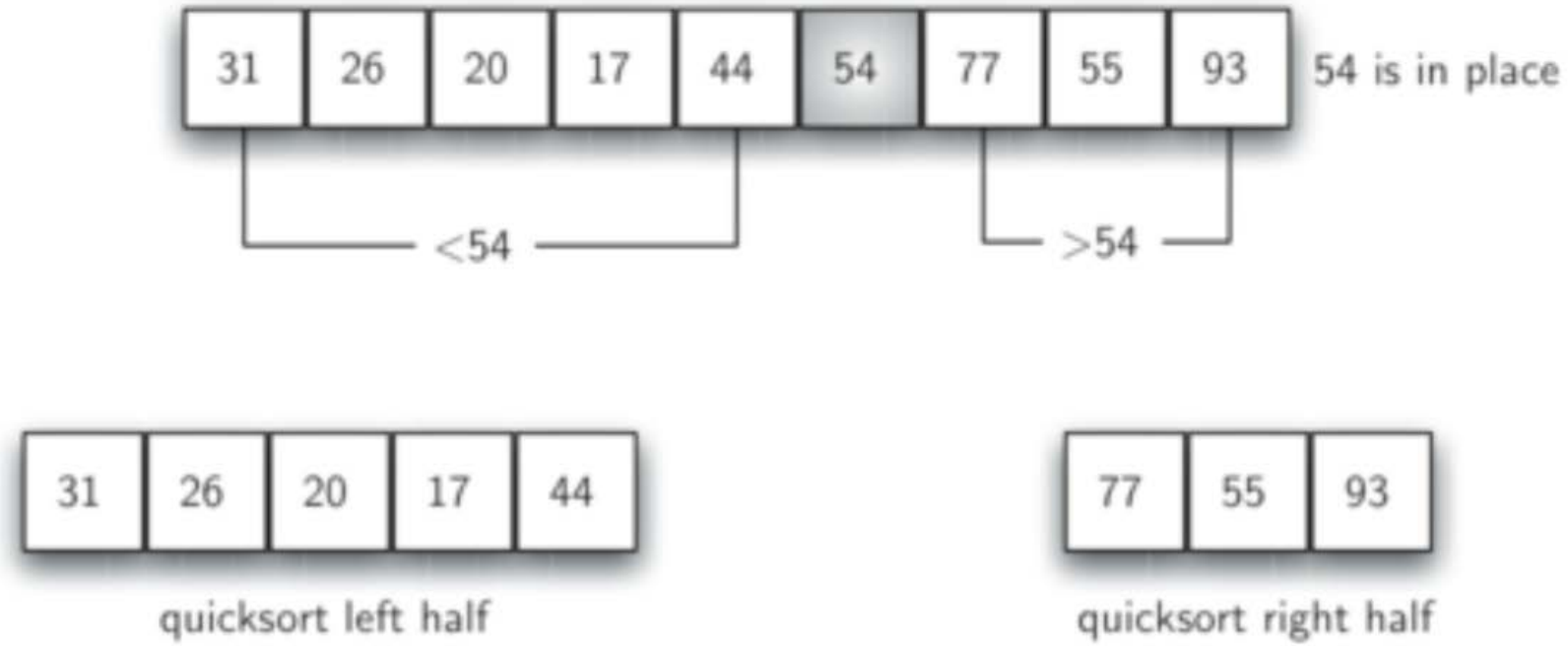
Quicksort

Keep exchanging positions within a list based on the "pivot value"



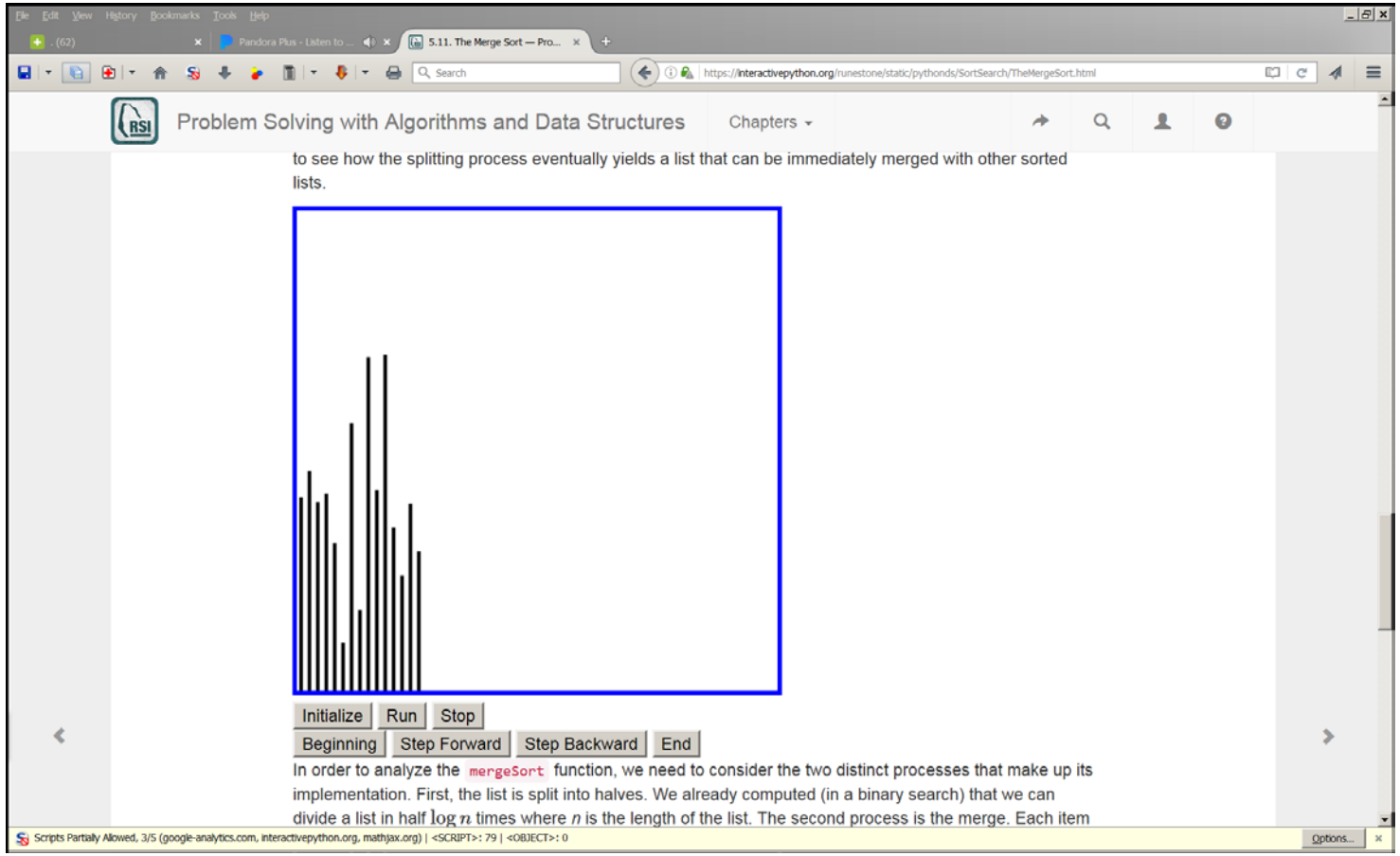
Quicksort

Keep exchanging positions within a list based on the "pivot value"
- then split into two lists and quicksorts them



Quicksort

https://interactivepython.org/runestone/static/pythonds/SortSearch/TheQuickSort.html
Along with mergesort and heapsort, a divide and conquer algorithm
Merge sorted lists, should be N $\log_2$ N
Exchange positions within a list based on a "pivot value"



Quicksort

```
# quicksort
def quickSort(alist):
   quickSortHelper(alist,0,len(alist)-1)

def quickSortHelper(alist,first,last):
   if first<last:

       splitpoint = partition(alist,first,last)

       quickSortHelper(alist,first,splitpoint-1) # recursive
       quickSortHelper(alist,splitpoint+1,last)  # recursive


def partition(alist,first,last):
   pivotvalue = alist[first]

   leftmark = first+1
   rightmark = last

   done = False
   while not done:

       while leftmark <= rightmark and alist[leftmark] <= pivotvalue:
           leftmark = leftmark + 1

       while alist[rightmark] >= pivotvalue and rightmark >= leftmark:
           rightmark = rightmark -1

       if rightmark < leftmark:
           done = True
       else:
           temp = alist[leftmark]
           alist[leftmark] = alist[rightmark]
           alist[rightmark] = temp

   temp = alist[first]
   alist[first] = alist[rightmark]
   alist[rightmark] = temp


   return rightmark

alist = [54,26,93,17,77,31,44,55,20] # list(range(900,0,-1))
quickSort(alist)
print(alist)
```

Homework 14

A. Gries 13.7 (page 266)

1, 3, 10 <<<< problem with question 10, this is the correct text;

10. In the function *merge* on page 261, there are two calls to extend. They are there because when the preceding loop ends, one of the two lists still has items in it that haven't been processed. Rewrite that loop so that these extend calls aren't needed.

AND:

B. Write a python program to sort a list by magnitude (absolute value). Ties are okay, but negatives should come before positives.

You can use any Python built-in methods (find, min, max, etc.)