Algorithms and Data Structures for Data Science
Sorting

CS 277
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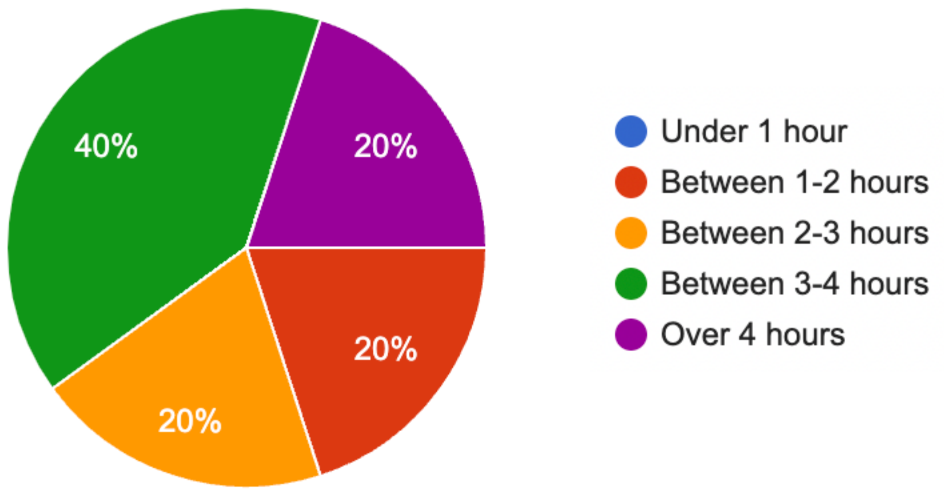
Lab_hash Feedback

Average score: 82%

PL average time: 163 minutes



Material of neutral helpfulness to a sizable minority of students

Lab taught learning objectives and universally improved coding confidence

There *was* a problem with double_hash but it was resolved immediately

Learning Objectives

Motivate the need for sorting

Explore iterative solutions to sorting

Introduce recursion

The Sorting Problem

Given a collection of objects, C, with comparable values, order the objects such that $\forall x \in C, x_i \leq x_{i+1}$

Input:

8	4	3	1	2	5	6	9	0	7

Output:

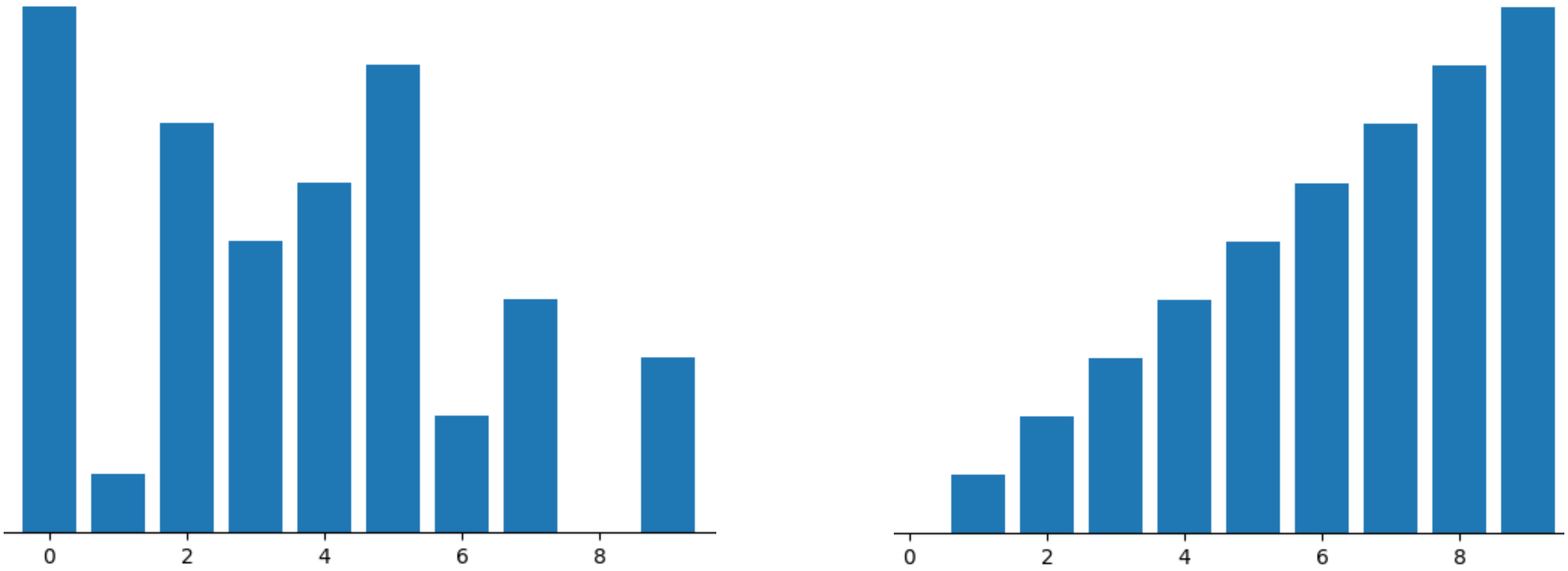
0	1	2	3	4	5	6	7	8	9

Sorting leads to efficient searching **`Search(7)`**

8	4	3	1	2	5	6	9	0	7

0	1	2	3	4	5	6	7	8	9

Sorting leads to better visualization



Sorting is a fundamental problem in CS

Many algorithms begin with or include a sorting step

Fundamental sorting algorithms are great for mastering concepts

Sorting algorithms are a classic introduction to algorithms

Optimizing sort is an ongoing challenge

GraySort: Sort rate (TBs / minute) achieved while sorting a very large amount of data (currently 100 TB minimum).

CloudSort: Minimum cost (Dollars) for sorting a very large amount of data on a public cloud. (currently 100 TB).

MinuteSort: Amount of data that can be sorted in 60 seconds or less.

TeraByeSort: Elapsed time to sort 1 TB of data

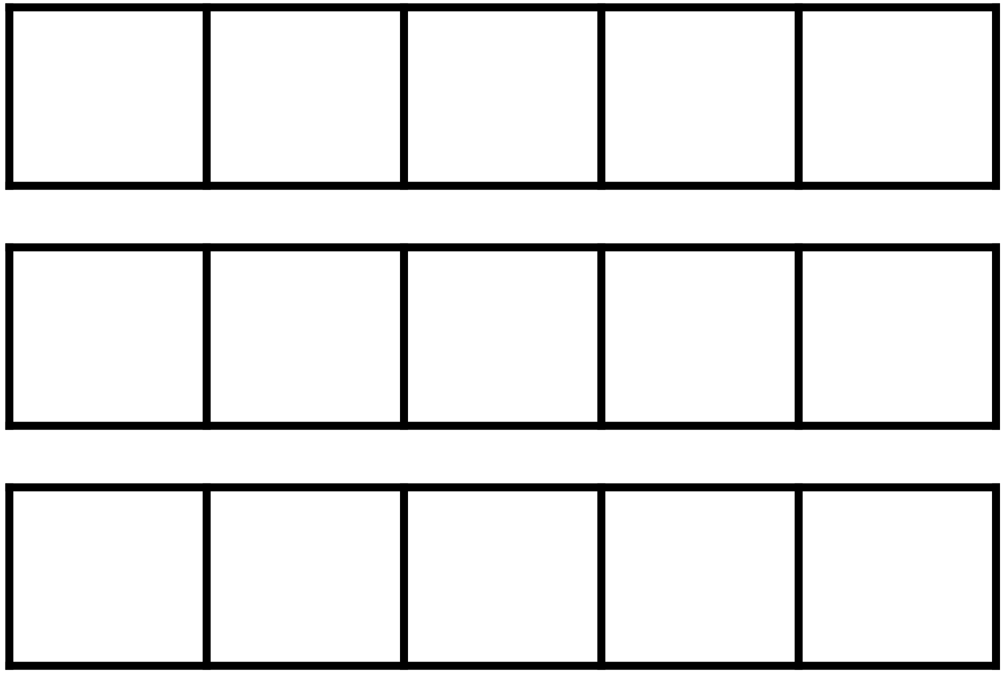
Competition details: http://sortbenchmark.org/

SelectionSort

```
def selectionSort(inList):
    n = len(inList)

    for i in range(n):
        mindex = i
        for j in range(i+1, n):
            if inList[j] < inList[mindex]:
                mindex = j

        inList[i], inList[mindex] = inList[mindex], inList[i]
```



InsertionSort

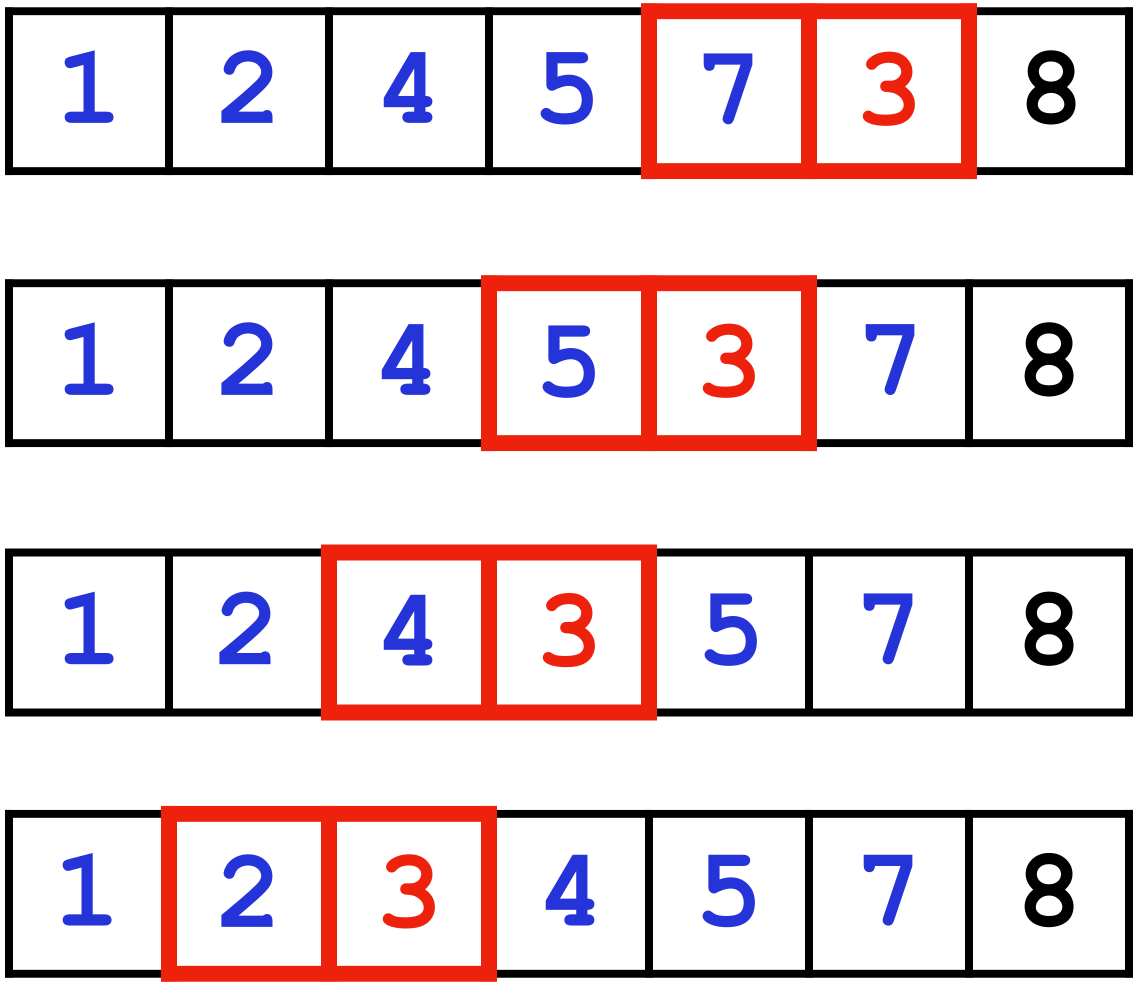
4	3	6	7	1

1. Divide array into two parts

2. Insert the first unsorted item into the sorted position

3. Repeat until all items are sorted

InsertionSort "Insert"



InsertionSort

```
def insertionSort(inList):
    n = len(inList)

    for i in range(1, n):

        val = inList[i]

        j = i - 1
        while j >= 0 and val < inList[j]:
            inList[j+1]=inList[j]
            j -= 1

        inList[j+1]=val
```

1	2	3	4	5

8	6	3	1	0

Selection vs InsertionSort

1	2	3	4	5

1	2	3	4	5

Selection vs InsertionSort

5	4	3	2	1

5	4	3	2	1

Selection vs InsertionSort

```
def selectionSort(inList):
    n = len(inList)

    for i in range(n):
        mindex = i
        for j in range(i+1, n):
            if inList[j] < inList[mindex]:
                mindex = j

        inList[i], inList[mindex] =
inList[mindex], inList[i]

```

```
def insertionSort(inList):
    n = len(inList)

    for i in range(1, n):

        val = inList[i]

        j = i - 1
        while j >= 0 and val < inList[j]:
            inList[j+1]=inList[j]
            j -= 1

        inList[j+1]=val
```

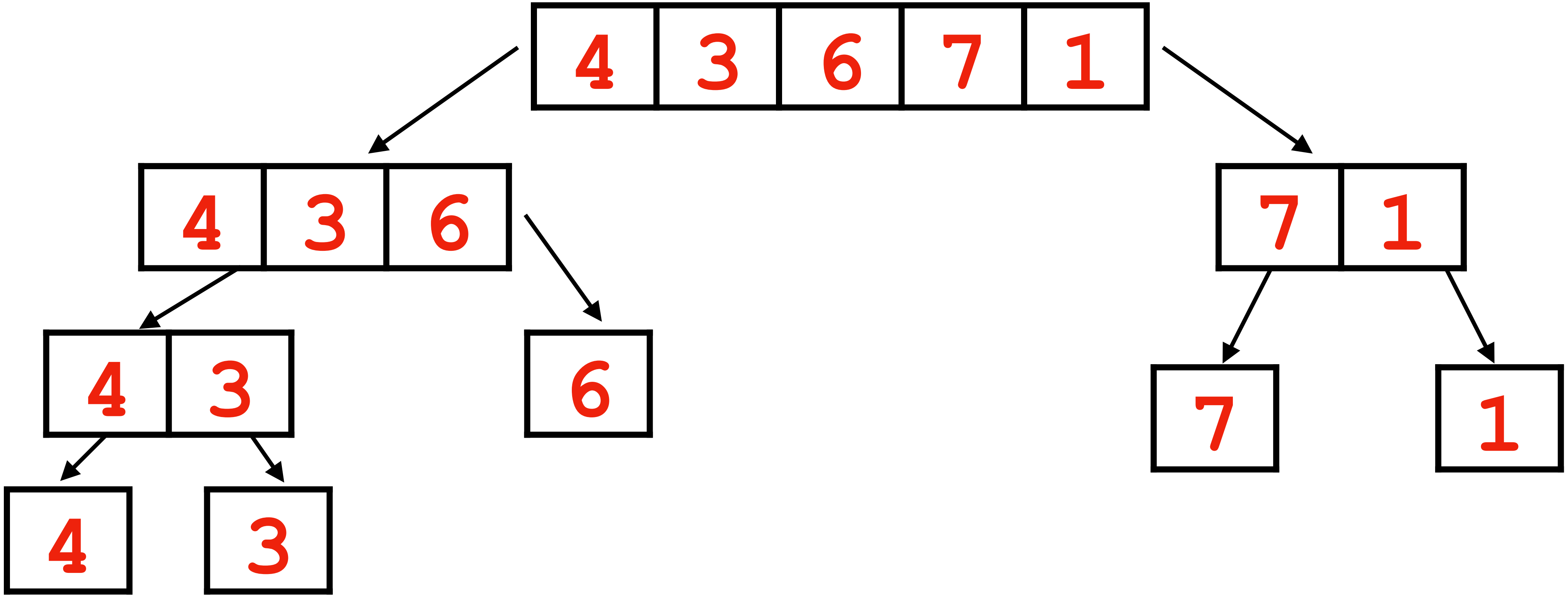
Optimal Sorting

Claim: Any deterministic comparison-based sorting algorithm must perform $O(n \log n)$ comparisons to sort n objects.

0	1	2	1	0	2	2	0	1
0	2	1	1	2	0	2	1	0

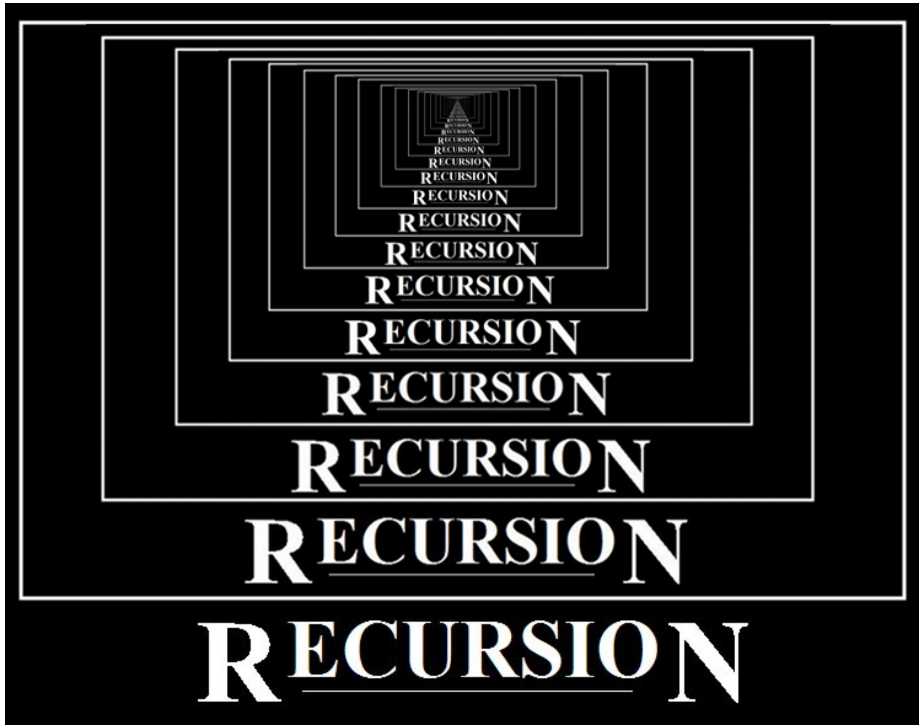
Divide and Conquer Algorithms

Recursively break a problem into sub-problems until the the problems become simple enough to solve directly



Recursion

The process by which a function calls itself directly or indirectly is called ***recursion.***



Recursive For Loop

```
for i in range(n+1):
    print(i)
```

```
def recursiveFor(n):
    if n == 0:
        print(n)
        return

    recursiveFor(n-1)

    print(n)
```

```
def recursiveFor(n):
    if n == 0:
        print(0)
        return

    print(n)

    recursiveFor(n-1)
```

Recursive Sum

Given a list, sum all the items in the list ***using recursion***

Base Case: What is the smallest sub-problem? What is the trivial solution?

Recursive Step: How can I reduce my problem to an easier one?

Combining: How can I build my solution from recursive pieces?

Recursive Sum

Given a list, sum all the items in the list ***using recursion***

8	4	2	6	5

Recursive findMax

8	4	3	1	2	5	6	9	0	7

Base Case:

Recursive Step:

Combining:

Recursive Fibonacci

$$Fib(n) = Fib(n-1) + Fib(n-2)\,, \quad n > 1$$

Base Case:

Recursive Step:

Combining:

Recursive List Partitioning

Using all elements in a list, can we make two lists which have equal sums?

6	5	4	2	7

1	1	1	1	1

2	3	3	3	1

Recursive List Partitioning

Using all elements in a list, can we make two lists which have equal sums?

Base Case:

Recursive List Partitioning

Using all elements in a list, can we make two lists which have equal sums?

Recursive Step:

Recursive List Partitioning

Using all elements in a list, can we make two lists which have equal sums?

(New) Base Case:

Recursive List Partitioning

Using all elements in a list, can we make two lists which have equal sums?

Combination Step:

Recursive List Partitioning

Using all elements in a list, can we make two lists which have equal sums?

4	3	1

Using all elements in a list, can we make two lists which have equal sums?

Input

[4, 3, 1] ([], [])

[3, 1] ([4], []) ([], [4])

[1] ([3, 4], []) ([4], [3]) ([3], [4]) ([], [3, 4])

[]

([1, 3, 4], []) ([1, 4], [3]) ([1, 3], [4]) ([1], [3, 4])

([3, 4], [1]) ([4], [1, 3]) ([3], [1, 4]) ([], [1, 3, 4])

Recursive Array Sorting

0	3	7	5	8	9	2	1	4	6

Base Case:

Recursive Step:

Combining: