

# Lecture 25

CSE 331

Nov 1, 2023

# Project deadlines coming up

Tue, Oct 31		(HW 5 in)
Wed, Nov 1	Multiplying large integers  <a href="#">F22</a>  <a href="#">F21</a>  <a href="#">F19</a>  <a href="#">F18</a>  <a href="#">F17</a> $x^2$	[KT, Sec 5.5] <i>Reading Assignment:</i> <a href="#">Unraveling the mystery behind the identity</a>
Fri, Nov 3	Closest Pair of Points  <a href="#">F22</a>  <a href="#">F21</a>  <a href="#">F19</a>  <a href="#">F18</a>  <a href="#">F17</a> $x^2$	[KT, Sec 5.4] (Project (Problems 1 & 2 <b>Coding</b> ) in)
Mon, Nov 6	Kickass Property Lemma  <a href="#">F22</a>  <a href="#">F21</a>  <a href="#">F19</a>  <a href="#">F18</a>  <a href="#">F17</a> $x^2$	[KT, Sec 5.4] (Project (Problems 1 & 2 <b>Reflection</b> ) in)

# Group formation instructions

## Autolab group submission for CSE 331 Project

The lowdown on submitting your [project](#) (especially the [coding](#) and [reflection](#)) problems as a group on Autolab.

Follow instructions **EXACTLY** as they are stated

**The instructions below are for Coding Problem 1**

You will have to repeat the instructions below for EACH coding AND reflection problem on project on Autolab (with the appropriate changes to the actual problem).

## Form your group on Autolab

**Groups on Autolab will NOT be automatically created**

You will have to form a group on Autolab by yourself (as a group). Read on for instructions on how to go about this.

# Do not use Join a Group “feature”

note @331 stop following 143 views Actions

## When forming groups on Autolab

I forgot to add this warning earlier but I have updated the [Autolab project page](#) to add a warning to **not click on the "Join a Group" function when you are creating your group on Autolab:**

**Do NOT click on `Join a Group`**

**Do NOT use the "Join a Group" feature. ONLY follow the instructions above EXACTLY.**

This step can be un-done but needs intervention on our part BUT that'll cause delays on your side and we are not responsible if you miss your deadline due to this delay.

Here is what such an option looks like (the actual group name and group members would be different in your case):

**Join a Group** ← Do NOT use this option

TAs\_(Java\_testers)

Gitanjali Nandi, Thomas Sherwood

[Ask to Join Group](#)

project autolab

# Please be in touch w/ your group

note @321

stop following

153 views

Actions

## Please respond to your project group mates

Please do respond back if a group project member reaches out to you to get started on the project. Just FYI, *I always reserve the right to kick you out of your group (which means a 0 for you) in case you are unresponsive to repeated requests from your group members.*

I understand some of you might be busy now-- it is fine with me if your group decide *as a whole* how the work will be divided (so e.g. someone does less work on the initial problems and someone does more work on the later problems). As long as the group agrees, I do not care about the details.

**But please do respond back in a timely fashion:** not doing so is you not doing your part in a group project.

project

Edit good note | 0

Updated 2 weeks ago by Atri Rudra

# 1-on-1 meeting slots

note @392

stop following **33 views**

Actions

## Meetings to discuss CSE 331 performance

By Sunday tonight, I will email those who have a D+ or below in their mid-term grade (for more details on the grade see @393) to setup a one-on-one meeting to talk with me but I figured I should post the information about meeting times now rather than tomorrow.

Of course you can also come and talk about your 331 performance even if you have a temp grade higher than D+ (though students with a D+ or below will get preference).

I have locked out certain times over next week or so for **15 mins** meetings. Please note that **these are NOT walk-ins**: if no one signs up for a slot, I will NOT be on zoom then. If you want to come and talk with me, **please EMAIL me with ALL the slots below that work for you**. (Private posts on piazza will not work: please email me!) *Slots will be assigned on a first-come-first-serve basis. Also I might only be able to confirm your time after 11pm on the day before your scheduled slot.*

**Note:** These are my current availabilities-- some of the slots might be used up in some other non-CSE 331 meetings. So please send multiple choices for when you can meet.

To make things easier, **ALL meeting will be on zoom** (<https://buffalo.zoom.us/j/96902087672?pwd=UXVxL21OQkdLYWd1VzdhdHFNBmlPdZ09>)

Below are all the available slots (below the start times are listed: a slot that is already taken has a strike-through):

- **Monday (Oct 30):** 9:00am, 9:15, 9:30, 9:45, 10:00, 12:30pm, 2:30, 2:45, 5:15, 5:30, 5:45, 6:00, 6:15, 6:30, 6:45
- **Tuesday (Oct 31):** 9:45am, 10:00am, 2:45pm
- **Wednesday (Nov 1):** 9:00am, 9:15, 9:30, 9:45, 10:00, 1:00pm, 1:15, 5:15, 5:30, 5:45, 6:00, 6:15, 6:30
- **Thursday (Nov 2):** 9:00am, 9:15, 9:30, 9:45, 10:00, 10:15, 10:30, 10:45, 11:00, 11:15, 11:30, 11:45, 12:00pm, 12:15, 12:30, 12:45, 1:00, 1:15
- **Friday (Nov 3):** 9:00am, 9:15, 9:30, 9:45, 10:00, 12:30pm

(Apologies but my schedule for this semester is bit of a mess. If none of the times above work for you but you still want to meet, please email me and we can set up a time for the week of Nov 5.)

You can of course also stop by during my office hours (but students with Qs on the HWs will get higher priority) and you unfortunately cannot book a slot during my usual office hours.

Again, **please email me your (at least top 3) choices** (again note the ALL slots are virtual).

mid-term grading

Edit good note 0

Updated 21 minutes ago by Atri Rudra

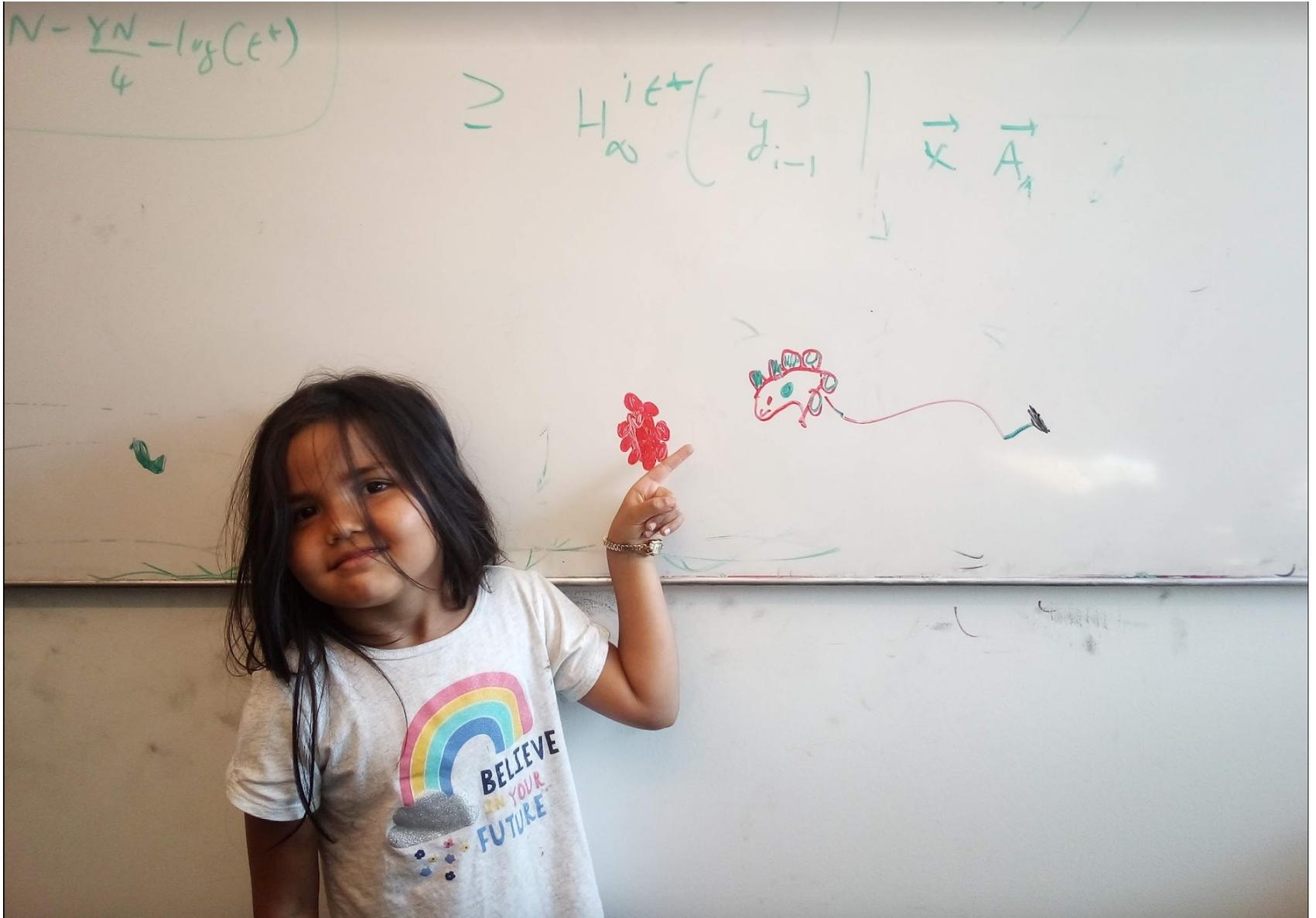
Resolved  Unresolved @392\_f3

Actions

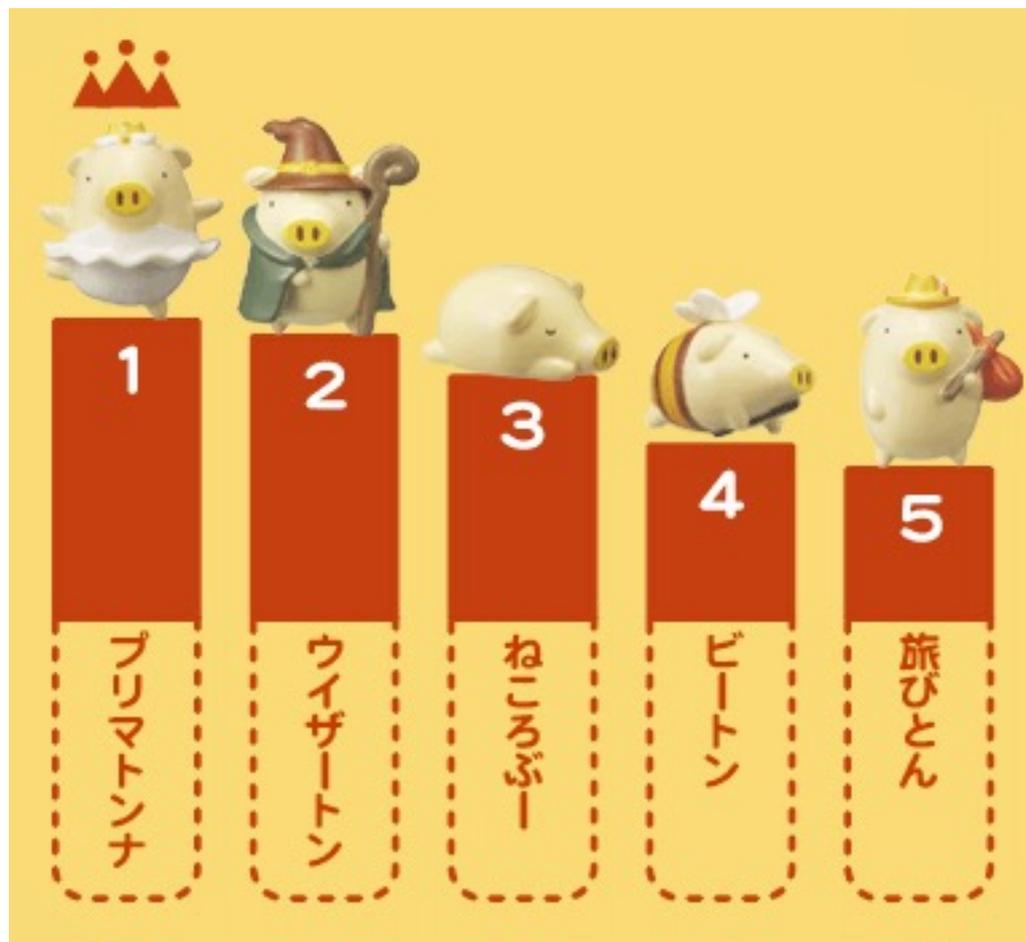
 **Atri Rudra** 18 hours ago

Since I had to cancel some of the slots today and Wed, I added some slots for next Monday, Nov 6. **However, you need to sign up for those slots by 5pm this Friday.**

# Questions/Comments?



# Rankings



# How close are two rankings?

Google   [Advanced Search](#)

Web [Show options...](#) Results 1 - 10 of about 23,700,000 for compare rankings. (0.30 seconds)

**Comparison Reviews** Sponsored Link  
[Angleslist.com](#) Your neighbors' ratings on local service companies. Award-winning.

**Ranking - Wikipedia, the free encyclopedia**  
In competition **ranking**, items that **compare** equal receive the same **ranking** number, and then a gap is left in the **ranking** numbers. The number of **ranking** ...  
[en.wikipedia.org/wiki/Ranking](#) - [Cached](#) - [Similar](#) - [Print](#) - [Share](#)

**A Comparison of Ranking Methods for Classification Algorithm Selection**  
is based on Spearman's rank correlation coefficient. To **compare ranking** methods, a combination of Friedman's test and Dunn's multiple com- ...  
[www.springerlink.com/ndex/mh87p44744x7Q258.pdf](#) - [Similar](#) - [Print](#) - [Share](#)  
by PB Brazdil - 2000 - [Cited by 46](#) - [Related articles](#)

**College Football Ranking Comparison**  
College Football **Ranking** Comparison. Sunday, November 8, 2009 (127 **Rankings**). | Last Week | Archived | FBS | FCS | Summary | CSV Data | ...  
[www.masseyratings.com/cf/compare.htm](#) - [Cached](#) - [Similar](#) - [Print](#) - [Share](#)

**College Basketball Ranking Comparison**  
Monday, April 6, 2009 (36 **Rankings**) ..... Cor 923 810 923 898 819 868 888 777 839 899 880  
243 246 245 248 241 251 247 249 248 244 **Ranking** Violation % 254 ...  
[www.masseyratings.com/cb/compare.htm](#) - [Cached](#) - [Print](#) - [Share](#)

**FIFA.com - Compare Teams**  
With FIFA.com you can **compare** the progress of up to four teams in the FIFA/Coca-Cola World **Ranking**. See how teams have risen and fallen since August 1993 ...  
[www.fifa.com/.../ranking/compare/compareteams.html](#) - [Cached](#) - [Similar](#) - [Print](#) - [Share](#)

**GetEducated.com | Rate, Rank & Compare Online Colleges & Degrees**  
GetEducated.com's directory of online degrees provides **rankings**, ratings, and comparison tools to help you choose the best online degrees from the best ...  
[www.geteducated.com/](#) - [Cached](#) - [Similar](#) - [Print](#) - [Share](#)

**Compare your website rankings in Google Caffeine « Advanced Web ...**  
Aug 18, 2009 ... To help you **compare** your website **rankings** from Google with the **rankings** from Google Caffeine we have created a quick step-by-step tutorial

Web Images Videos Shopping News Maps More MSN Hotmail

bing

**ALL RESULTS** ALL RESULTS 1-10 of 8,810,000 results · [Advanced](#)

**FIFA.com - Compare Teams**  
With FIFA.com you can **compare** the progress of up to four teams in the FIFA/Coca-Cola World **Ranking**. See how teams have risen and fallen since August 1993 and pinpoint their ...  
[www.fifa.com/worldfootball/ranking/compare/compareteams.html](#) · [Cached page](#)

**How to Compare Graduate School Rankings | eHow.com**  
Choosing a graduate school can be a stressful and confusing process for any student. By comparing graduate schools and their **rankings** a student can choose which one fits her ...  
By eHow Education Editor · Difficulty: Moderate · 0 posts  
[www.ehow.com/how\\_2051516\\_compare-graduate-school-rankings.html](#) · [Cached page](#)

**Ranking - Wikipedia, the free encyclopedia**  
Items that **compare** equal receive the same **ranking** number, which is the mean of what they would have under ordinal **rankings**. Equivalently, the **ranking** number of 1 plus the number of ...  
[en.wikipedia.org/wiki/Ranking](#) · [Enhanced view](#)

**Ranking Compare**  
Ask Google Yahoo Search | Web browser tool – Shows search results for a given keyword or phrase on the top three engines, Google, Yahoo and Msn.  
[tools.essential-seo.com/ranking-compare](#) · [Cached page](#)

**SchoolDigger.com - School Rankings, Reviews and More - Public and ...**  
Find the best elementary, middle, and high schools. Search for schools near any address, **compare** test scores, sort by school **ranking**, class sizes, and more using SchoolDigger.  
[www.schooldigger.com](#) · [Cached page](#)

**College and university rankings - Wikipedia, the free encyclopedia**  
The College and university **rankings** are a lists of universities and liberal arts colleges in higher education, an order determined by any combination of factors.  
International ... · Regional and national ... · Criticism (North America)  
[en.wikipedia.org/wiki/College\\_and\\_university\\_rankings](#) · [Enhanced view](#)

**www.hospitalcompare.hhs.gov**  
[www.hospitalcompare.hhs.gov/Hospital/Search/SearchCriteria.asp?version=default&browser=IE...](#)

# Rest of today's agenda

Formal problem: Counting inversions

Divide and Conquer algorithm

# Problem definition on the board...



# Solve a harder problem

Input:  $a_1, \dots, a_n$

Output: LIST of all inversions

```
L =  $\phi$ 
for i in 1 to n-1
  for j in i+1 to n
    if  $a_i > a_j$ 
      add (i,j) to L
return L
```



Optimal for  
the listing  
problem

# Example 1: All inversions-- $(2i-1, 2i)$

2	1	3	4	6	5	7	8
---	---	---	---	---	---	---	---

Only check  $(i, i+1)$  pairs

Q1: Solve listing problem in  $O(n)$  time?

Q2: Recursive divide and conquer algorithm to count the number of inversions?

CountInv ( $a, n$ )

if  $n = 1$  return 0

if  $n = 2$  return  $a_1 > a_2$

$a_L = a_1, \dots, a_{\lfloor n/2 \rfloor}$

$a_R = a_{\lfloor n/2 \rfloor + 1}, \dots, a_n$

return CountInv( $a_L, \lfloor n/2 \rfloor$ ) + CountInv( $a_R, n - \lfloor n/2 \rfloor$ )

# Can be horribly wrong in general

CountInv (a,n)

if  $n = 1$  return 0

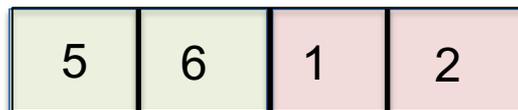
if  $n = 2$  return  $a_1 > a_2$

$a_L = a_1, \dots, a_{\lfloor n/2 \rfloor}$

$a_R = a_{\lfloor n/2 \rfloor + 1}, \dots, a_n$

return CountInv( $a_L, \lfloor n/2 \rfloor$ ) + CountInv( $a_R, n - \lfloor n/2 \rfloor$ )

Example where instance has non-zero (can be  $\Omega(n^2)$ ) inversions and algo returns 0?



All 4 "crossing" pairs are inversions

# Bad case: “crossing inversions”

CountInv (a,n)

if  $n = 1$  return 0

if  $n = 2$  return  $a_1 > a_2$

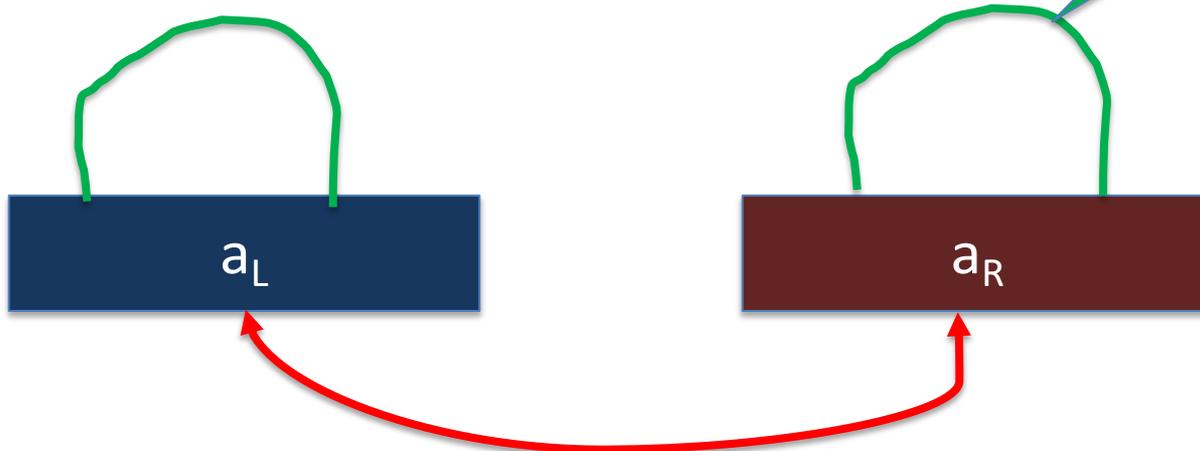
$a_L = a_1, \dots, a_{\lfloor n/2 \rfloor}$

$a_R = a_{\lfloor n/2 \rfloor + 1}, \dots, a_n$

return CountInv( $a_L, \lfloor n/2 \rfloor$ ) + CountInv( $a_R, n - \lfloor n/2 \rfloor$ )

Yes!

Are  $a_L$   
and  $a_R$   
sorted?



# Example 2: Solving the bad case



$a_L$



$a_R$

$a_L$  is sorted

First element in  $a_L$  is larger than first/only element in  $a_R$

$O(1)$  algorithm to count number of inversions?

return size of  $a_L$

# Example 3: Solving the bad case

1
---

$a_L$

5	6	.....
---	---	-------

$a_R$

$a_R$  is sorted

First/only element is  $a_L$  is smaller than first element in  $a_R$

$O(1)$  algorithm to count number of inversions?

return 0

# Solving the bad case

First element of  $a_L$  is larger than first element of  $a_R$



$a_L$



$a_R$

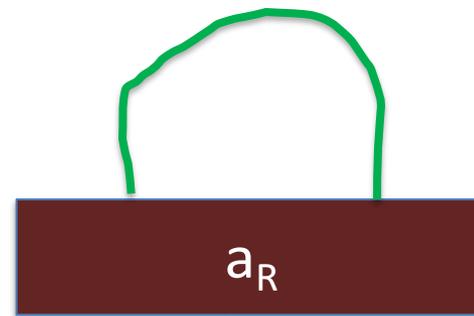
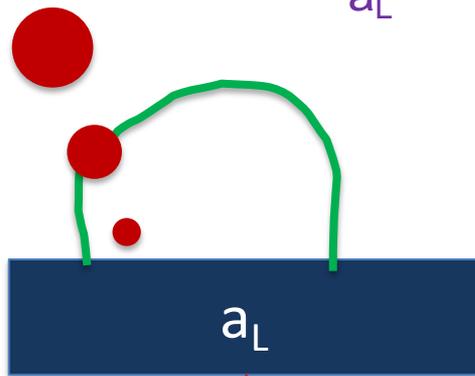
First element of  $a_L$  is smaller than first element of  $a_R$



$a_L$



$a_R$



Try to  
modify  
the  
MERGE  
algorithm



# Divide and Conquer

Divide up the problem into at least two sub-problems

Solve all sub-problems: Mergesort

Recursively solve the sub-problems

Solve stronger sub-problems: Inversions

“Patch up” the solutions to the sub-problems for the final solution

# MergeSortCount algorithm

Input:  $a_1, a_2, \dots, a_n$

Output: Numbers in sorted order+ #inversion

```
MergeSortCount( a, n )
```

```
  If  $n = 1$  return ( 0 ,  $a_1$  )
```

```
  If  $n = 2$  return (  $a_1 > a_2$ ,  $\min(a_1, a_2)$ ;  $\max(a_1, a_2)$  )
```

```
   $a_L = a_1, \dots, a_{n/2}$      $a_R = a_{n/2+1}, \dots, a_n$ 
```

```
  (  $c_L$ ,  $a_L$  ) = MergeSortCount( $a_L$ ,  $n/2$ )
```

```
  (  $c_R$ ,  $a_R$  ) = MergeSortCount( $a_R$ ,  $n/2$ )
```

```
  (  $c$ ,  $a$  ) = MERGE-COUNT( $a_L, a_R$ )
```

```
  return (  $c + c_L + c_R$ ,  $a$  )
```

$$T(2) = c$$

$$T(n) = 2T(n/2) + cn$$

$O(n \log n)$  time

$O(n)$

Counts #crossing-inversions+  
MERGE

# MERGE-COUNT( $a_L, a_R$ )

$a_L = l_1, \dots, l_{n'}$

$a_R = r_1, \dots, r_m$

$c = 0$

$i, j = 1$

while  $i \leq n'$  and  $j \leq m$

if  $l_i \leq r_j$

add  $l_i$  to output

$i++$

else

add  $r_j$  to output

$j++$

$c += n' - i + 1$

Output any remaining items

return  $c$



$a_L$



$a_R$



$a_L$



$a_R$