

Week 1: Wednesday

EECS 183



Maxim Aleksa '17

maximal@umich.edu

maximal.io

Romance Languages, Computer
Science, Business

iWork team at Apple

Web development

iOS, macOS, tvOS, watchOS apps

Photography, Italianissimo, linguistics, tennis, traveling



Lab section

Review

New examples

Practice problems

Exam-style questions

Handouts

Project tips

Lab assignments

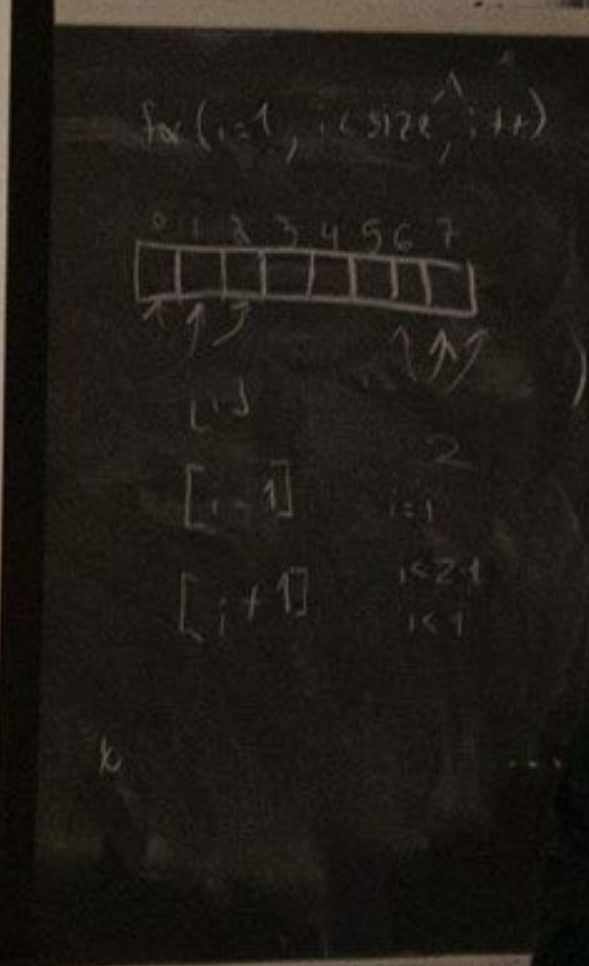
Q&A



Lab section

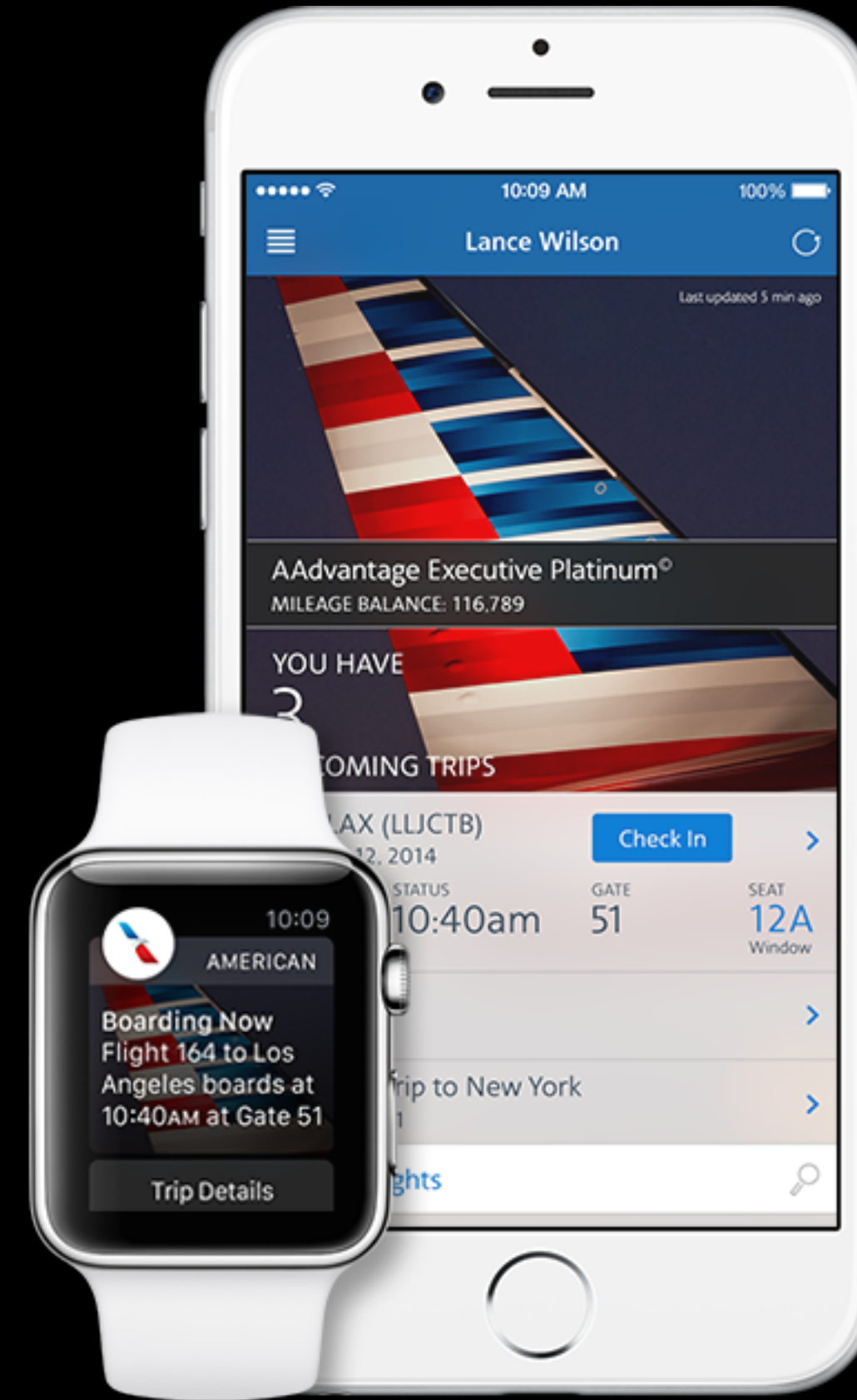
Arrays

```
type name[SIZE];
```



Cool things

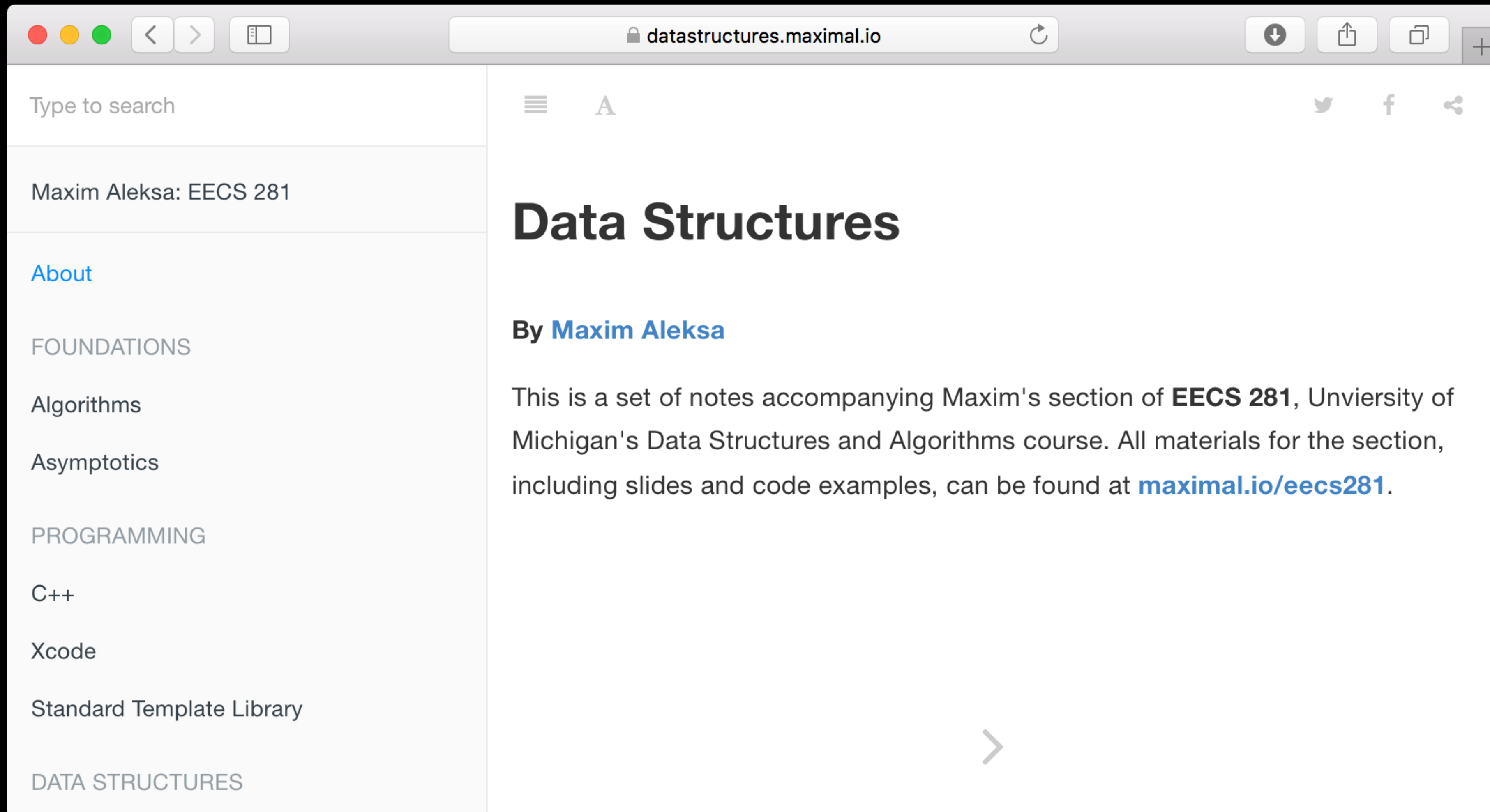
HTML



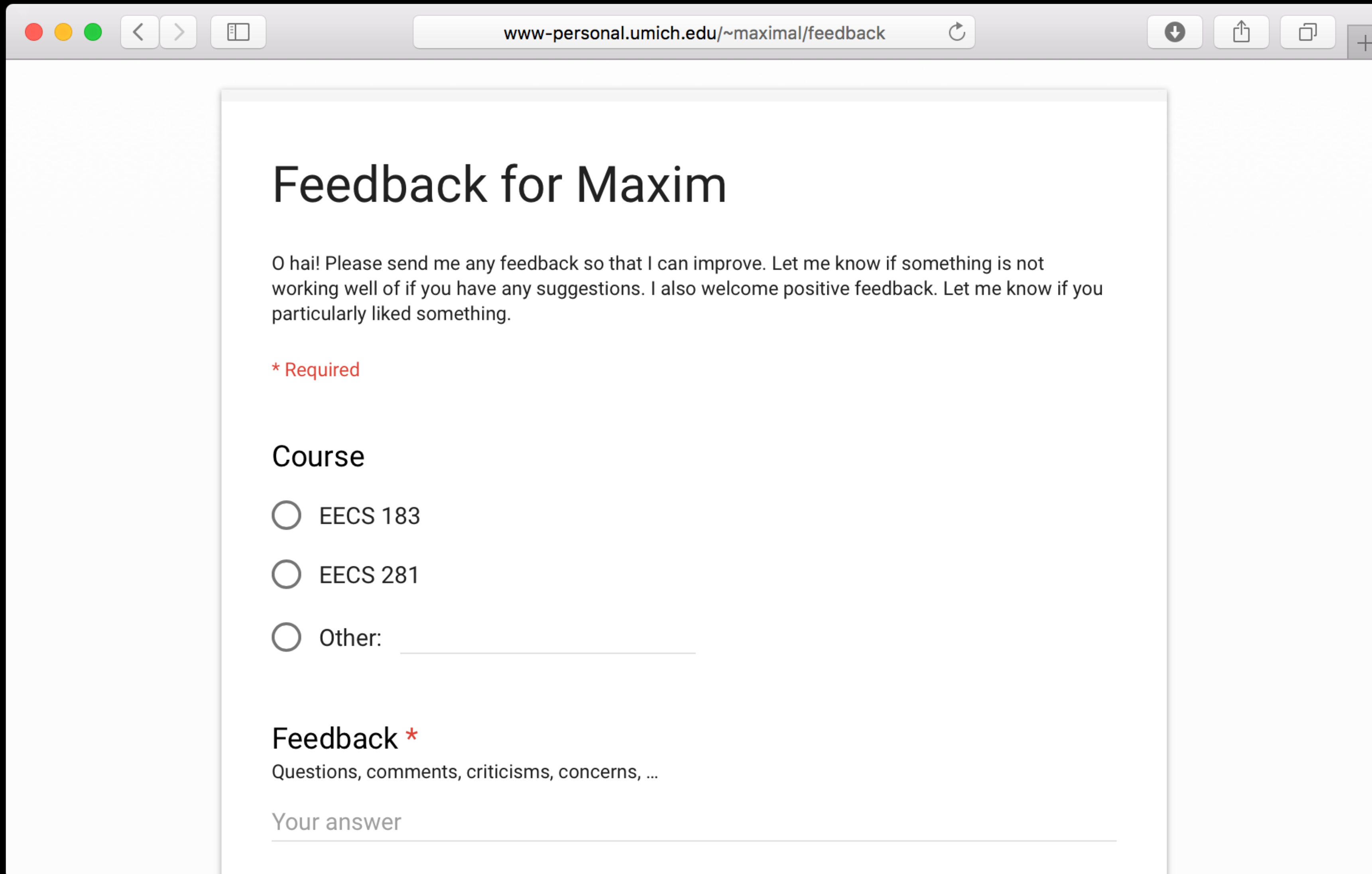
`maximal.io/eeecs281`

slides, notes, source code, links, et cetera

datastructures.maximal.io



maximal.io/feedback



The screenshot shows a web browser window with the address bar displaying `www-personal.umich.edu/~maximal/feedback`. The page content is a feedback form titled "Feedback for Maxim". The form includes a welcome message, a list of radio buttons for course selection (EECS 183, EECS 281, and Other:), a required feedback text field, and a text area for the user's answer.

Feedback for Maxim

O hai! Please send me any feedback so that I can improve. Let me know if something is not working well of if you have any suggestions. I also welcome positive feedback. Let me know if you particularly liked something.

* Required

Course

☐ EECS 183

☐ EECS 281

☐ Other: _____

Feedback *

Questions, comments, criticisms, concerns, ...

Your answer _____

A blurred background image of a classroom. A male teacher in a maroon shirt stands at the front, gesturing with his hands. Several students are seated at desks, some with laptops open. The image is out of focus, emphasizing the text overlay.

Office Hours

Central campus and North campus

Agenda

Introduction

Algorithms

Asymptotics

Getopt

Makefile

Valgrind

Data Structures

Computational thinking

inputs $\rightarrow$ algorithms $\rightarrow$ outputs



Algorithm cost

Given a sorted array A , find indices i and j where $A[i] = A[j]$.

-3	-1	2	4	5	8	10	12
----	----	---	---	---	---	----	----

Algorithm cost

Given a sorted array A , find indices i and j where $A[i] = A[j]$.

-3	-1	2	4	5	8	10	12
----	----	---	---	---	---	----	----

Create a list of all pairs and iterate through pairs:

$(-3, -1), (-3, 2), (-3, 4), \dots, (10, 12)$

Algorithm cost

Given a sorted array A , find indices i and j where $A[i] = A[j]$.

-3	-1	2	4	5	8	10	12
----	----	---	---	---	---	----	----

Better algorithm:

Compare each number $A[i]$ with $A[i + j]$.

Running times

input size	n	$n \log_2 n$	n^2	n^3	1.5^n	2^n	$n!$
$n = 10$	< 1 sec	< 1 sec	< 1 sec	< 1 sec	< 1 sec	< 1 sec	4 sec
$n = 30$	< 1 sec	< 1 sec	< 1 sec	< 1 sec	< 1 sec	18 min	10^{25} years
$n = 50$	< 1 sec	< 1 sec	< 1 sec	< 1 sec	11 min	36 years	very long
$n = 100$	< 1 sec	< 1 sec	< 1 sec	1 sec	12,892 years	10^{17} years	very long
$n = 1,000$	< 1 sec	< 1 sec	1 sec	18 min	very long	very long	very long
$n = 10,000$	< 1 sec	< 1 sec	2 min	12 days	very long	very long	very long
$n = 100,000$	< 1 sec	2 sec	3 hours	32 years	very long	very long	very long
$n = 1,000,000$	1 sec	20 sec	12 days	31,710 years	very long	very long	very long

Adapted from Table 2.1, p. 34 of Jon Kleinberg and Eva Tardos. 2006. *Algorithm Design*. Pearson Education, Inc.

Asymptotics

How fast is this code?

```
int count = 0;
for (int i = 0; i < N; ++i) {
    if (arr[i] == 0) {
        ++count;
    }
}
```

Give the best answer using Big O, Big Omega or Big Theta.

Asymptotics

maximal.io/section

How fast is this code?

Room

EECS183

```
int count = 0;
for (int i = 0; i < N; ++i) {
    if (arr[i] == 0) {
        ++count;
    }
}
```

some times
 $0 \leq x \leq N$

N times

Give the best answer using Big O, Big Omega or Big Theta.

$\Theta(N)$

$N + 0 \leq$

$\leq N + N$

Summary

	Big O $O(f(n))$	Big Omega $\Omega(f(n))$	Big Theta $\Theta(f(n))$
Informal meaning	Order of growth is less than or equal to $f(n)$	Order of growth is greater than or equal to $f(n)$	Order of growth is $f(n)$
Example family	$O(N^2)$	$\Omega(N^2)$	$\Theta(N^2)$
Family members	$N^2 / 2$ $2N^2 + 1$ $\log(N)$	$N^2 / 2$ $2N^2 + 1$ e^N	$N^2 / 2$ $2N^2 + 1$ $N^2 + 183N + 5$

Summary

$n \in O(n^2)$
upper bound

$n^2 \in \Omega(n)$
lower bound

$n^2 + 2 \in \Theta(n^2)$
tight bound

	Big O $O(f(n))$	Big Omega $\Omega(f(n))$	Big Theta $\Theta(f(n))$
Informal meaning	Order of growth is less than or equal to $f(n)$	Order of growth is greater than or equal to $f(n)$	Order of growth is $f(n)$
Example family	$O(N^2)$	$\Omega(N^2)$	$\Theta(N^2)$
Family members	$N^2 / 2$ $2N^2 + 1$ $\log(N)$	$N^2 / 2$ $2N^2 + 1$ e^N	$N^2 / 2$ $2N^2 + 1$ $N^2 + 183N + 5$

Let $R(N)$ be the runtime of this code as a function of N .

```
bool hasDuplicates(const int numbers[], int size) {  
    for (int i = 0; i < size; i += 1) {  
        for (int j = 0; j < size; j += 1) {  
            if (numbers[i] == numbers[j]) {  
                return true;  
            }  
        }  
    }  
    return false;  
}
```

What is the order of growth of $R(N)$?

A. $R(N) \in \Theta(1)$.

B. $R(N) \in \Theta(N)$.

C. $R(N) \in \Theta(N^2)$.

D. Something else

Let $R(N)$ be the runtime of this code as a function of N .

```
bool hasDuplicates(const int numbers[], int size) {  
    for (int i = 0; i < size; i += 1) {  
        for (int j = 0; j < size; j += 1) {  
            if (numbers[i] == numbers[j]) {  
                return true;  
            }  
        }  
    }  
    return false;  
}
```

maximal.io/section

Room EECS 183

N is size

What is the order of growth of $R(N)$?

A. $R(N) \in \Theta(1)$.

B. $R(N) \in \Theta(N)$.

C. $R(N) \in \Theta(N^2)$.

D. Something else

Let $R(N)$ be the runtime of this code as a function of N .

```
bool hasDuplicates(const int numbers[], int size) {  
    for (int i = 0; i < size; i += 1) {  
        for (int j = i + 1; j < size; j += 1) {  
            if (numbers[i] == numbers[j]) {  
                return true;  
            }  
        }  
    }  
    return false;  
}
```

What is the order of growth of $R(N)$?

A. $R(N) \in \Theta(1)$.

B. $R(N) \in \Theta(N)$.

C. $R(N) \in \Theta(N^2)$.

D. Something else

Project 1

due Tuesday 5/9

IDE (integrated development environment)



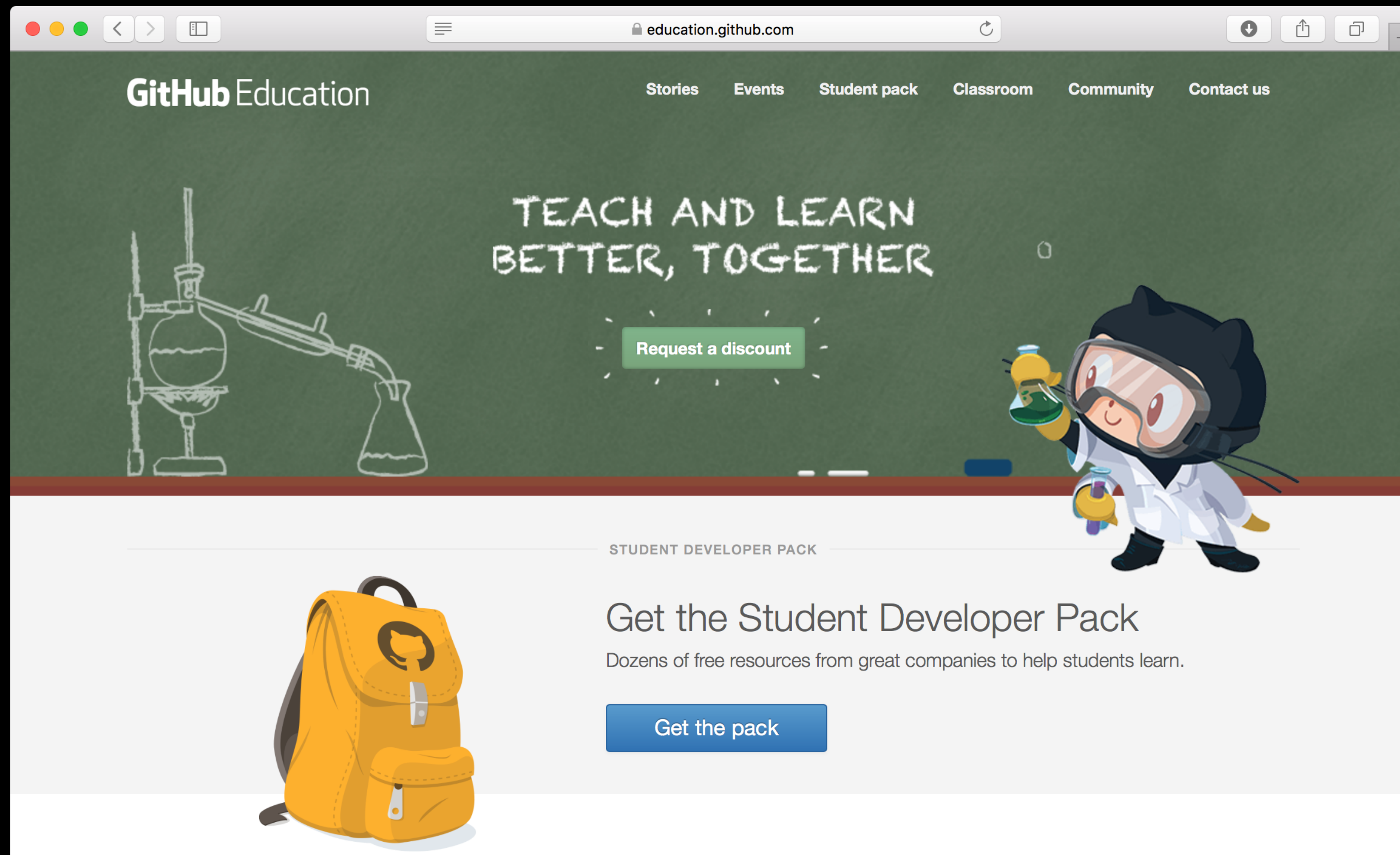
eecs183.org/xcode



eecs183.org/vs

Git

education.github.com



Xcode

Redirect file to cin:

```
freopen("input01.txt", "r", stdin);
```

Also go to Product > Scheme > Edit Scheme > Run (on the left) > Options (at the top), and set the **custom working directory** to where your input files are located.

Select Arguments at the top and include any **command-line arguments** you want to pass to your program on launch.

I/O

Add `ios_base::sync_with_stdio(false);`

Use `ostringstream` for output.

getopt
ls -la dir

getopt

```
#include <getopt.h>

int main(int argc, char * argv[]) {

    struct option longOpts[] = {
        {"help", no_argument, nullptr, 'h'},
        {"output", required_argument, nullptr, 'o'},
        {nullptr, 0, nullptr, '\0'}
    };

    // parse options
}
```

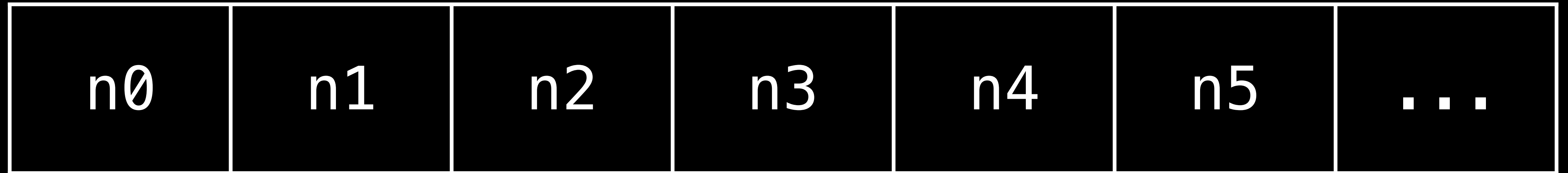
getopt

```
char option;
int index = 0;
while ((option = getopt_long(argc, argv, "ho:", longOpts, &index)) != -1) {
    switch (option) {
        case 'h':
            // print help message
            break;
        case 'o':
            // decide output
            break;
        default:
            cerr << "Invalid option: " << option << endl;
            break;
    }
}
```

Queues and stacks



Vector



```
#include <vector>
vector::push_back(...)
vector::resize(...)
vector::reserve(...)
```

Vector

$v = [1 | 2 | 3 | 4] [0 | 0 | 0 | 0]$
 $v.resize(8)$

n0	n1	n2	n3	n4	n5	...
----	----	----	----	----	----	-----

$v.at(6)$

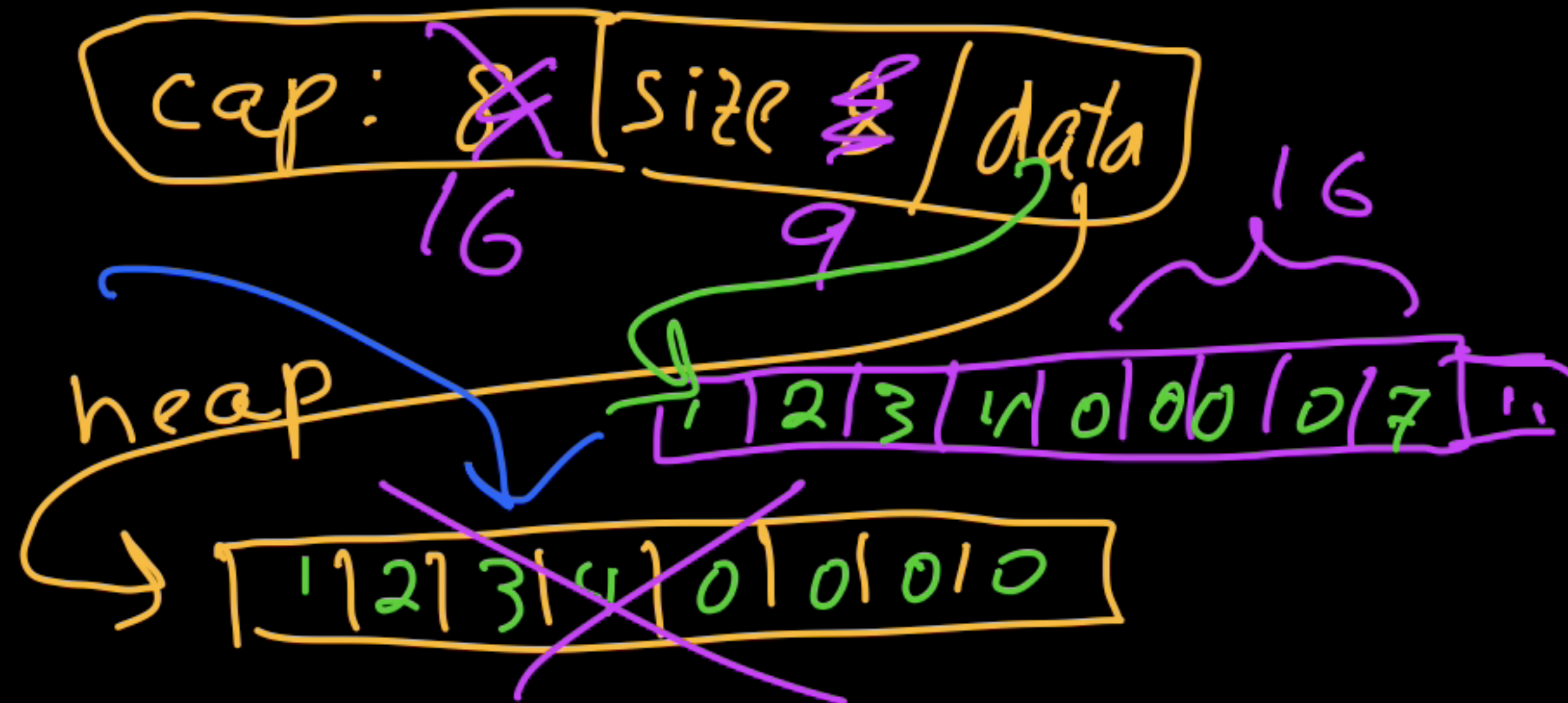
Stack

```
#include <vector>
```

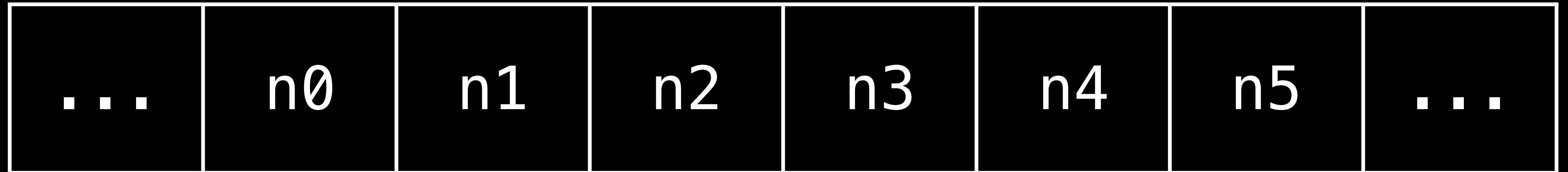
```
vector::push_back(...)
```

```
vector::resize(...)
```

```
vector::reserve(...)
```



Deque



```
#include <deque>
```

```
deque::push_front(...)
```

```
deque::push_back(...)
```

Deque

```
#include <deque>
using namespace std;
// ...
deque<int> numbers;
numbers.push_back(280);
numbers.push_back(281);
numbers.push_front(183);
```

Makefile

```
make fullsubmit
```

Makefile

Makefile from Project 0

Change **EXECUTABLE**

Change **PROJECTFILE**

Execute `make fullsubmit` for project + test files

Execute `make partialsubmit` for project

CAEN

```
ssh username@login.engin.umich.edu
```

Configure GCC:

```
cd  
cat >> .bash_profile  
module load gcc/5.1.0
```

Tips

Write `double speed;` atop your code.

Start projects early.

Come to office hours to work on projects.

Use classes and test them before adding to project.

Attend lectures and lab sections. 😊

Lab 1

`lab1.cpp`

Implement a program that reads numbers and prints average

- Two TODOs in `getMode`
- Implement `readWithResize`
- Implement `readWithReserve`
- Implement `readWithNoSize`

Submit `lab1.cpp`

Submit Canvas quiz

Boyer–Moore majority vote algorithm

```
/**
 * Changes most to be a potential majority element.
 * Returns true if most is a majority element,
 * otherwise returns false.
 * The .size() of the data vector must be at least 1.
 */
template <typename T>
bool mooresVoting(const vector<T> &data, T &most) {
    // TODO
}
```