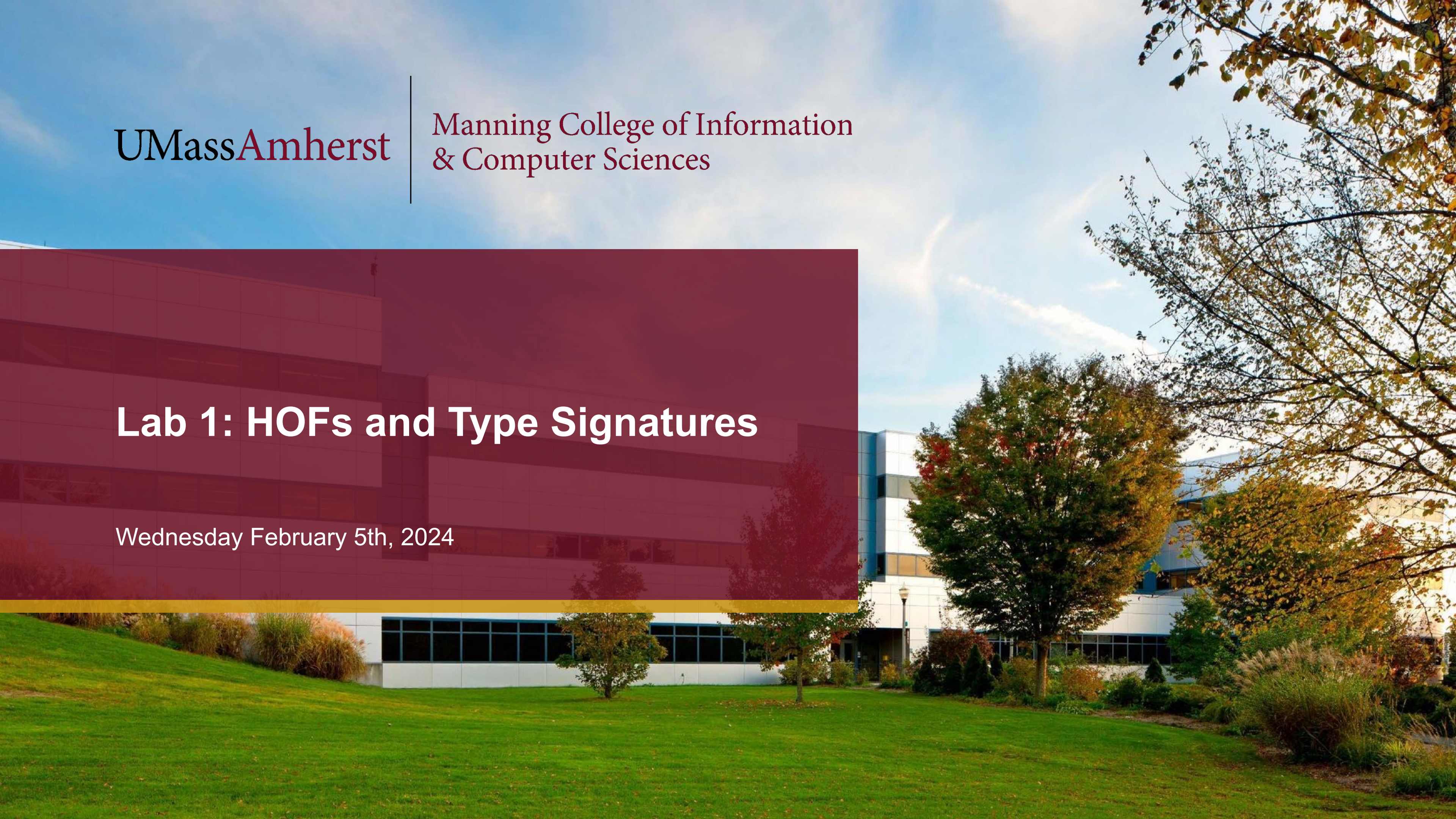
UMass Amherst | Manning College of Information & Computer Sciences

Lab 1: HOFs and Type Signatures

Wednesday February 5th, 2024



Weekly Lab Agenda

- Go over reminders/goals
- Review past material
- Work in groups of 2-3 to solve a few exercises
    - Discussion leaders will assign groups today
    - Groups will be remade every third lab
- Discussion leaders will walk around and answer questions
- Solutions to exercises will be reviewed as a class
- Attendance taken at the end

Reminders

- Please set up your development environment as soon as possible
- Homework 1 is due tonight at 11:59pm
- If you need to miss lab and have a valid reason according to the syllabus (medical, other personal) please fill out the questionnaire on Canvas before the start time of your lab.
    - Waking up late, bus was late are NOT valid reasons to miss lab.
- Submit what you have at the end of lab to Gradescope. If you miss many submissions to Gradescope, we may penalize your lab grade.

Lab Groups

- You will now be assigned into your lab groups
- Please sit with your group each week

- Take the next 5 minutes to talk to each other
- Introduce yourselves!
  - Name, pronouns, major
  - Favorite household appliance
  - What was one fun thing you did over break?

Today's Goals

- Set up coding environment
- Practice both higher-order functions and some TypeScript
- Walk out with some working code

Writing and Running TypeScript

- Download the starter code from GitHub (linked on Canvas).
- Unzip the folder and open it in VSCode.
- Run *npm install* in the same directory as the package.json folder.
- When you are ready to submit, run *npm run build:submission*
- Upload the resulting zip file to the corresponding assignment on gradescope.

- Your lab leaders will walk you through this process for the first lab!

Review of map

```
// Sample Implementation
// `.map` is a method on Arrays
function map<T, U>(
  a: T[],
  f: (x: T) => U
): U[] {
  const result: U[] = [];
  for (let i = 0; i < a.length; ++i) {
     result.push(f(a[i]));
  }
  return result;
}
```

```
function double(x: number): number {
     return 2 * x;
}

const array = [1,2,3,4,5];
const newArray = array.map(double);
```

What is `newArray` ?

Reason about the code before typing and running it.

Review of filter

```
// Sample Implementation
// `.filter` is a method on Arrays
function filter<T>(
  a: T[],
  f: (x: T) => boolean
): T[] {
  const result: T[] = [];
  for (let i = 0; i < a.length; ++i) {
     const x = a[i];
     if (f(x)) {
       result.push(x);
     }
  }
  return result;
}
```

```
function isEven(x: number): boolean {
     return x % 2 === 0;
}
const array = [1,2,3,4,5];
const newArray = array.filter(isEven);
```

What is `newArray` ?

Reason about the code before typing and running it.

Programming Exercise 1

Write a function that takes an array of number arrays, and returns an array of number arrays where all negative values have been removed. Again, don’t use any loops or recursion.

`[[1,-2,3], [0], [0,1,2,3], []]` → `[[1,3],[0], [0,1,2,3], []]`

A number array is typed as `number[]`, an array of those is `number[][]`

Review of Type Signatures

We can infer types based on the operations done on values

```
// f(x: number, y: number): number     or  f: (number, number) => number
function f(x, y) {
  return x + (2*y);
  // product with y: y is number, x and result is number
}
```

Sometimes, we have several possibilities

```
// g: (number, number) => number    or    g: (string, string) => string
function g(x, y) { return x + y; }  // + can be string concatenation

// h(a: string): boolean   or   h<T>(a: T[]): boolean
function h(a) { return a.length > 5; } // both strings & arrays have length
```

The array could have any element type. We call T a **type variable.**
This lets us write **generic functions.**

Exercise 2: Type Signatures

What is the type signature for the following code?

```
const h = (a, g, f) => f(a.map(g)).filter(g);
```

Start by considering an arbitrary element type for the array, and continue to derive types for the map and filter callback functions.

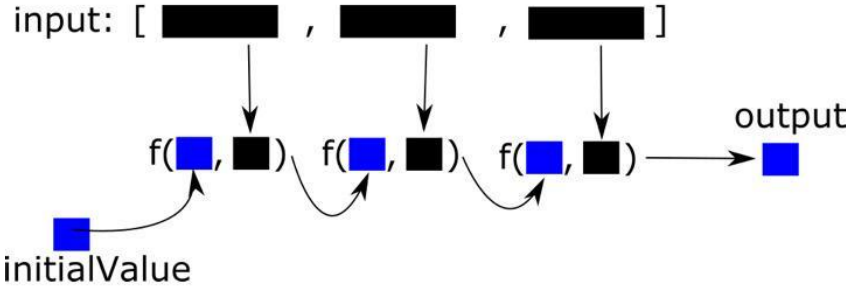
Remember:

```
map<A,B>(arr: A[], f: (x: A) => B): B[]

filter<T>(arr: T[], f: (x: T) => boolean): T[]
```

Review of Reduce

```
function reduce<T, U>(
     a: T[],
     f: (acc: U, e: T) => U,
     init: U
): U {
     let result = init;
     for (let i = 0; i < a.length; ++i) {
          result = f(result, a[i]);
     }
     return result;
}
```



Reduce is used to combine array elements with the same function.

Example: Find the product of all elements of an array a = [3, 2, 6, 2, 2, 0]

```
a.reduce((prod, e) => prod * e, 1);
```

Exercise 3: Map, Filter & Reduce

Write a function without using loops or recursion to calculate the sum of the square roots of all positive numbers in an array.

Note: Use Math.sqrt() to calculate the square root

Example: Input: [-6, 0, 4, 16, -5] => Output: 2 + 4 = 6

Final Thoughts

- Think carefully about your approach before starting to code
- Start small and test often
- Try to make use of as much of your previous work as possible

- A lot of material all at once, come to office hours if you are confused
    - We would love to see you there! 😄
- It is okay if some of us take longer or don’t finish before lab ends, keep working at it
    - Try not to get discouraged
- Starting the homework today is not required, but try to get into the habit of reading the instructions as soon as they are released