Course Introduction

Concepts of Programming Languages

Lecture 1

CAS CS 320

Outline

- Discuss the logistics of the course
- Give an overview of what PL is about
- Take a first look at OCaml

Course Logistics

Course Staff

Instructors: Nathan Mull & Ankush Das (me)

Teaching Fellows: Sam Silverman & Ugur Yavuz

Course Assistants: Miranda Quimbar & Shiyun Yang

Office Hours will be posted on website soon

Lectures

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- If something is said in lecture and not on Piazza there is no excuse for missing the information
- Barring technical issues, lectures will be **recorded**

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- All lab material is fair game for exams

Grade Breakdown

20%	Assignments	(6 total, 1 dropped, 4% each)
16%	In-Class Quiz	(Sep 30 & Nov 18, 1 dropped)
24%	Mini-Projects	(3 total, no drops, 8% each)
20%	Midterm Exam	(Oct 16, 2025 during class)
20%	Final Exam	(Date TBD, Cumulative)

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  - We reserve the right to dock points for not following instructions

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- If you have logistical questions (e.g., about disability accommodations) send us an email directly

Course Webpage

The webpage contains readings, assignments and labs. **Please check it frequently for updates**

https://nmmull.github.io/CS320/landing/Fall-2025/index.html

Course Repository

The course repo contains starter code and lecture material

In **Lab 1,** you'll set up a mirror of this repository for assignment submission

https://github.com/BU-CS320/cs320-fall-2025

Course Standard Library

We'll assume a very basic standard library for the course

You'll need to familiarize yourself with what's there during this first half

You'll install it during Lab 1 (Tomorrow)

Questions?

If we missed anything, ask on Piazza

Make sure you're on Piazza and Gradescope, checking the course webpage, and pulling down the course repo frequently

By continuing in this course you're agreeing to all these conditions

One Last Thing

Remember to be kind. This is a difficult course. Don't take it out on other students (or us)

We care about your success in this course, we’re here to help

Use your best judgment, you're adults

What is this Course About?

Theme of the Course

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- This is a course on “Programming Languages” (PL).
- You’ll learn “**Programming Abstractions**”, i.e., high-level constructs to make programming easier (e.g., loops, functions, arithmetic)

What is a PL?

Fair Question

How would you define a PL?

How would you explain it to your roommate?

How would you answer if you were asked during an interview?

Discuss this with the people around you for 1 min

Programmer's view of a PL

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This is not what the course is about

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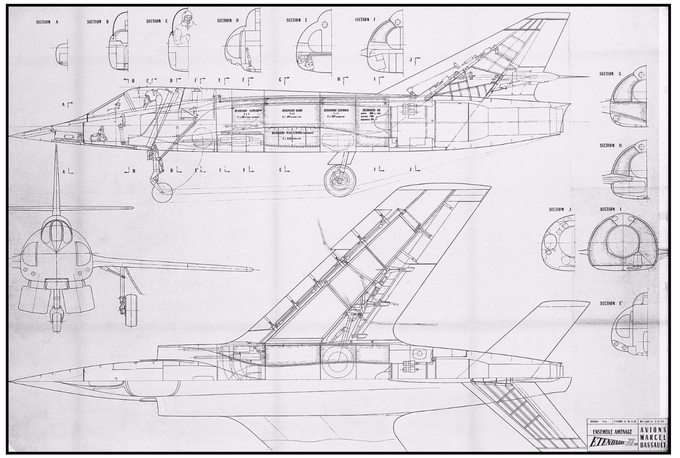

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Programmers *use* PLs. We're interested in **designing** PLs

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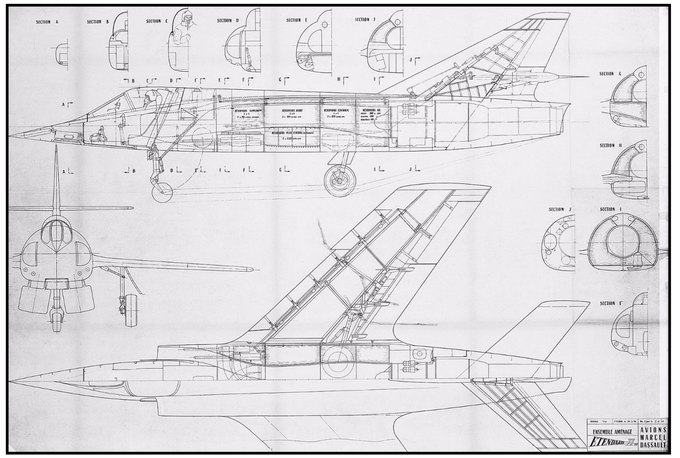

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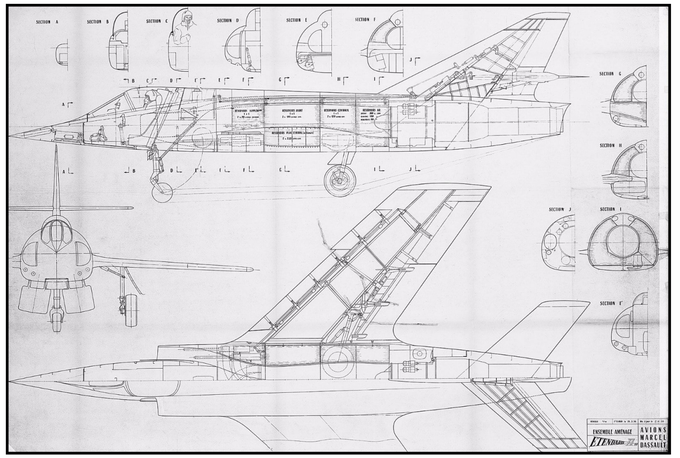

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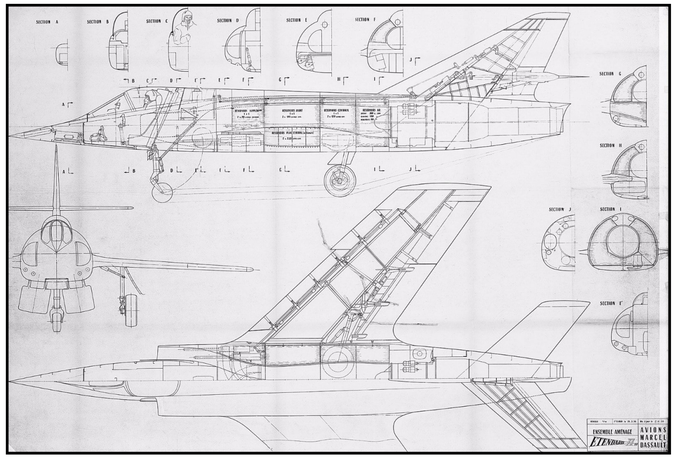

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(CS320 is secretly a math class, sorry)

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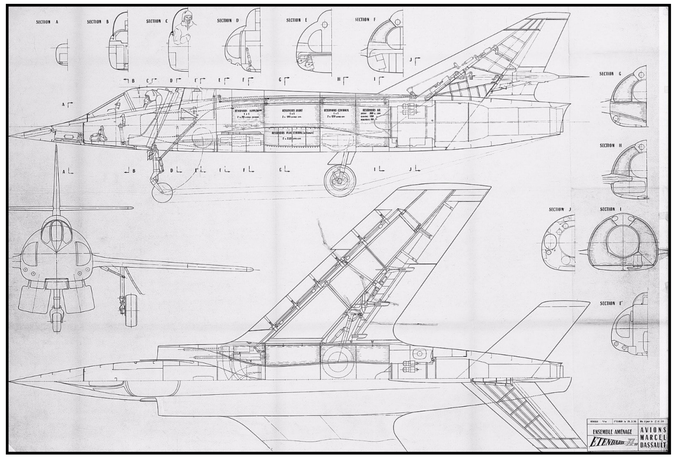

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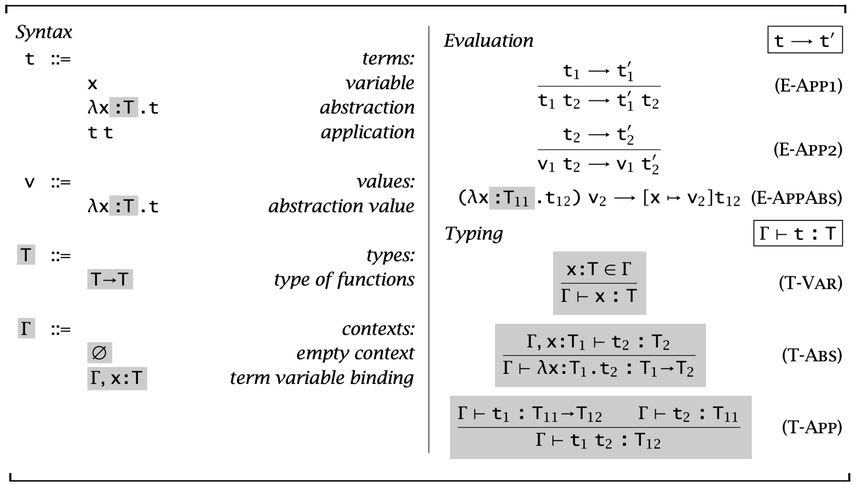

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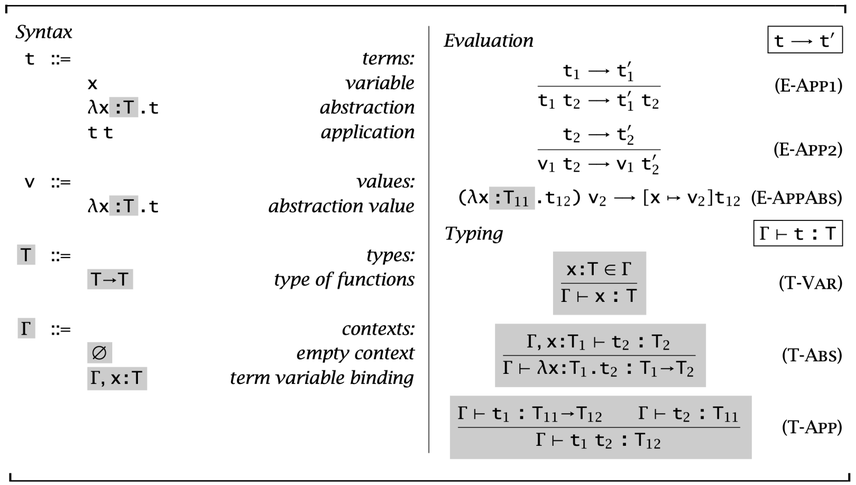

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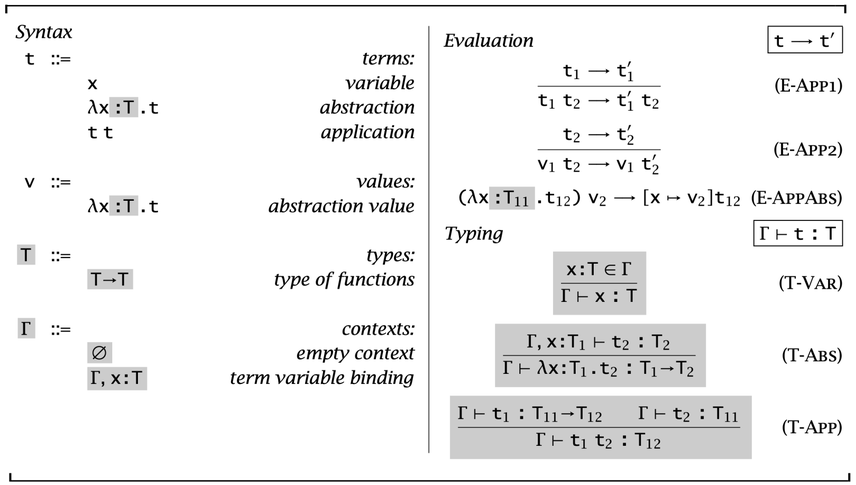

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Mathematician's View of PL

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» composed of exactly three things:

- Syntax
- Type System
- Semantics

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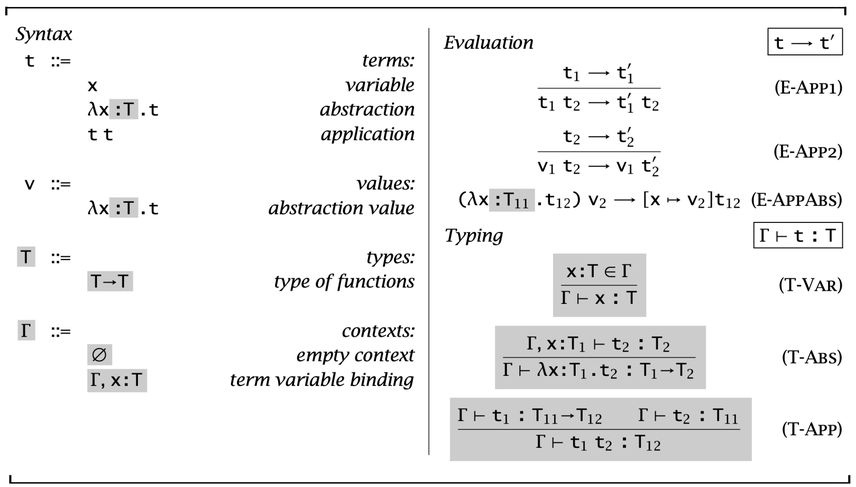

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Gist: ***a good PL has a mathematically well-defined syntax, type system, and semantics***

Definition of a PL

The Three Components

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Syntax: What a *well-formed* program in your PL?

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    return 3
```

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def ()f:
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Semantics: What is the *output* of a (valid) program?

```
>>> 2 + 2
4
```

```
>>> 2 + 2
False
```

For everything we do from now on, we'll define the syntax rules, the typing rules, and the semantic rules

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A syntax rule will almost always be of the form:

*If **<something>** is a well-formed expression and **<some-other-things>** are a well-formed expression, then **<some-combination-of-something-and-some-other-things>** is a well-formed expression*

Example: Integer Addition Syntax

If e_1 is a well-formed expression and e_2 is a well-formed expression, then e_1 + e_2 is a well-formed expression

In formal notation:

```
<expr> ::= <expr> + <expr>
```

Typing Rules

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If ***<something>*** *is of* ***<some-type>*** *and* ***<some-other-things>*** *are of* ***<some-other-types>****, then* ***<some-combination-of-something-and-some-other-things>*** *is of* ***<some-different-type>***

Example: Integer Addition Typing

If e_1 *is an* `int` *(in any context* Γ*) and* e_2 *is an* `int` *then (in any context* Γ*)* $e_1 + e_2$ *is an* `int` *(in any context* Γ*)*

In formal notation:

$$\frac{e_1 : \text{int} \qquad e_2 : \text{int}}{e_1 + e_2 : \text{int}} \text{ (addInt)}$$

Semantic Rules

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They will almost always be of the form:

If **<something>** evaluates to **<some-value>** and **<some-other-things>** evaluate to **<some-other-values>** then **<some-combination-of-something-and-some-other-things>** evaluates to **<some-other-value-computed-based-on-some-value-and-some-other-values>**

Example: Integer Addition Semantics

If e_1 *evaluates to the (integer)* v_1 *and* e_2 *evaluates to the (integer)* v_2*, then* $e_1 + e_2$ *evaluates to the (integer)* $v_1 + v_2$

In mathy notation:

$$\frac{e_1 \Downarrow v_1 \qquad e_2 \Downarrow v_2}{e_1 + e_2 \Downarrow v_1 + v_2}\ \text{(evalInt)}$$

We'll come back to all this soon...

What Language to Use for the Course?

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- **Minimality:** The language is simple, there's very little to it

- **Functional:** A completely different paradigm. We're not writing procedures via commands/statements, we're defining values via expressions

Overview

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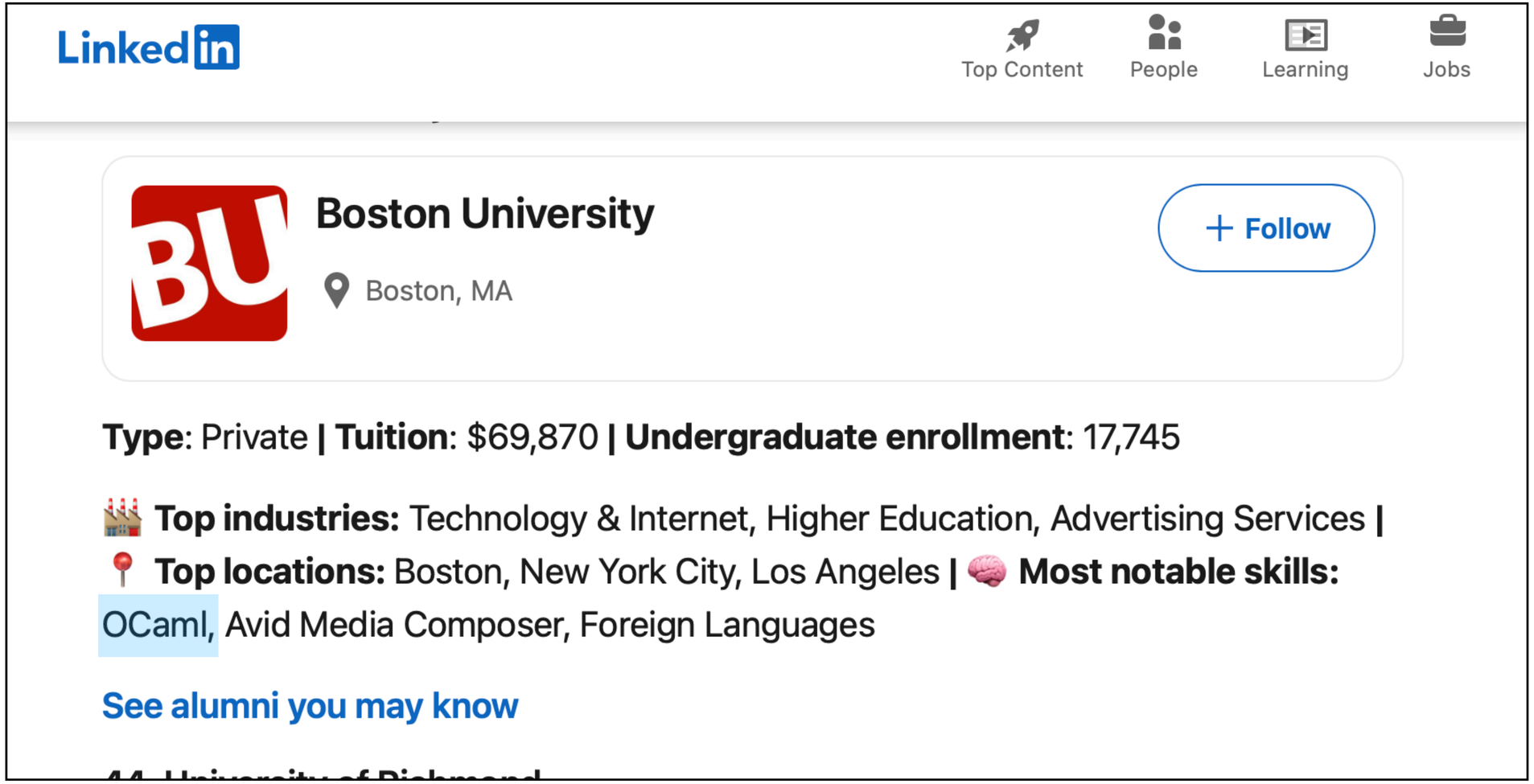
- OCaml is a statically-typed functional programming language
- It is industrial-strength: lots of documentation, tutorials, stack overflow posts
- It won the ACM SIGPLAN Programming Languages Software Award in 2023
- It's used/developed heavily by Jane Street (and to a lesser degree by Bloomberg, Meta, Docker, Wolfram)

Aside: OCaml is a "notable skill" we provide!



LinkedIn Top Colleges 2025: The 50 best colleges for long-term career success in the U.S.

Functional vs. Imperative

OCaml is a functional language. This means a couple things:

- No state (which means no loops!)
- We don't think of a program as describing a procedure, but a function taking an input and producing an output

A Note on State

```python
def fact(n):
    acc = 1
    for i in range(1, n + 1): # i is "stateful"
        acc *= i
    return acc
```

In Python, we can define variables that change throughout the evaluation of the program

We can't do this in OCaml. Instead we use **recursion**(!)

If you can write recursive functions, then you can program in OCaml

The Point

Imperative programs define how to update state by a sequence of commands

Function programs define what the output is for a given input

Every imperative program can be made functional by "simulating" loops using recursion

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```
parse : string -> expr
```

» **Type system** is implemented by a **type checker**

```
type_check : expr -> bool (* valid or not *)
```

» **Semantics** is implemented by an **evaluator**

```
eval : expr -> value
```

Next Steps

- Make sure you're on Piazza and Gradescope, keep an eye on announcements
- Bookmark the course webpage and course repo
- Install opam, VSCode, the course standard library, etc. *(go to lab tomorrow)*
- **Do the reading listed on the course webpage**

Summary

A PL is a mathematical object given by its **syntax, type system** and **semantics**

There is **no state** in functional programming. Programs define the output for a given input

Practice, practice, practice. Functional programming takes time to learn, but once you get it, it's as easy as programming in any other PL