Course Introduction

Rust, in Practice and in Theory
Lecture 1

CAS CS 392 (M1)

Outline

- Discuss the expectations of this course
- Look at what this course is about
- **Workshop:** Install Rust
- **If you finish:** Set up a Cargo project

Course Information

Minutiae

Instructor: Nathan Mull

Course Webpage: https://nmmull.github.io/CS392-S25/index.html

Midterm Date: March 6

Grade Breakdown

30%	Assignments
40%	Final Project (4 parts, 10% each)
20%	Midterm Exam (in class)
10%	Participation

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I am *not* an expert of Rust. I'm learning a lot myself. But I'm an expert in **type theory**. My goal is to show you all how *I* learn PLs

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I want this course to be very collaborative. I'll expect that you're working in groups, pair/group programming, and one-on-one discussions with me and the other students

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Assignments will consist of either programming exercises or larger programming tasks in Rust. We may have 1-2 written assignments

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Even if you pair/group program a problem, try to type your own solution and cite who you worked with

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It has four parts: (1) parser, (2) evaluator, (3) type/borrow checker, (4) extension of your choosing (you cannot drop any part)

By the end of the course, you should have a working interpreter

Participation

The participation part of the grade is made up of:

» Attendance

» Pre-lecture quizzes

» Participation in class discussion and online

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(If you convince me you've learned something, you'll almost certainly get an A in the course)

Course Communication

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We have a Piazza page for the course, please keep an eye on it for course-related updates

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I won't respond to emails regarding material, but you can email me if you have logistical questions

Course Webpage

https://nmmull.github.io/CS392-S25/index.html

The course webpage will have all material, links to reading, etcetera

Make sure to check it frequently

Questions?

If I miss anything, ask on Piazza

Remember: This is a *small, experimental* course. If you have suggestions on the course, please let me know

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

Last thing: What's your name?

Name:

Year:

Interest in CS:

Interest outside of CS:

Take <u>1 minute</u> to think about it, and then we'll go around the room

What is this course?

The Idea

If you took CS320 last semester, then the concept should be familiar:

1. **Learn Rust** (a somewhat difficult PL)

2. **Implement Rust** (in Rust, to check our understanding)

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Some things will move very slow (We'll dwell a bit on things like memory management)

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It's an **alternative to C or C++** which can be used in production settings for rapid development without fear of crashes or memory leaks

About Rust

Developed by Graydon Hoare out of Mozilla in the 2000s (originally implemented in OCaml)

It became stable (in particular with its type system) in the late 2010s

The Rust Foundation was started in 2021 and is the basis for Rust information and adoption today

It's community members are called **Rustacians**, which is the basis for the unofficial mascot **Ferris** the crab

Mozilla

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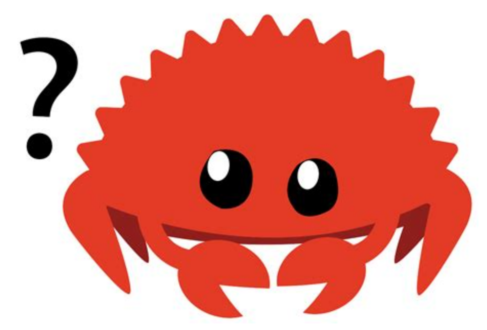
2. Rust is becoming *popular*

   Firefox, Dropbox, Yelp, Amazon (along with lots of others) are all adopting Rust in large-scale projects

Example: Rust being Weird



```c
void swap(char **x, char **y) {
  char *z = *x;
  *x = *y;
  *y = z;
}
```

C

```rust
fn swap(x : &mut String, y : &mut String) {
  let z : String = *x;
  *x = *y;
  *y = z;
}
```

Rust

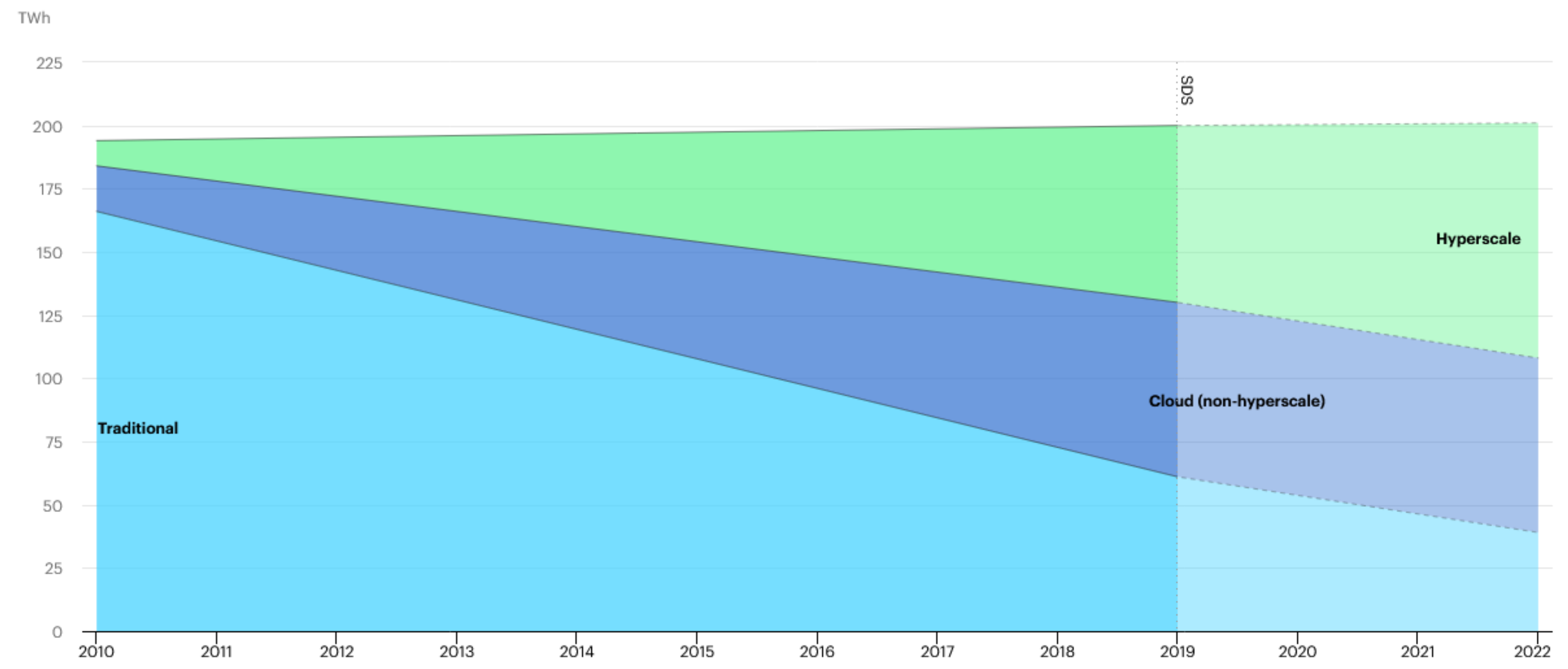
Rust has a notion of references, but it's *not possible* to write the swap-string-pointer function

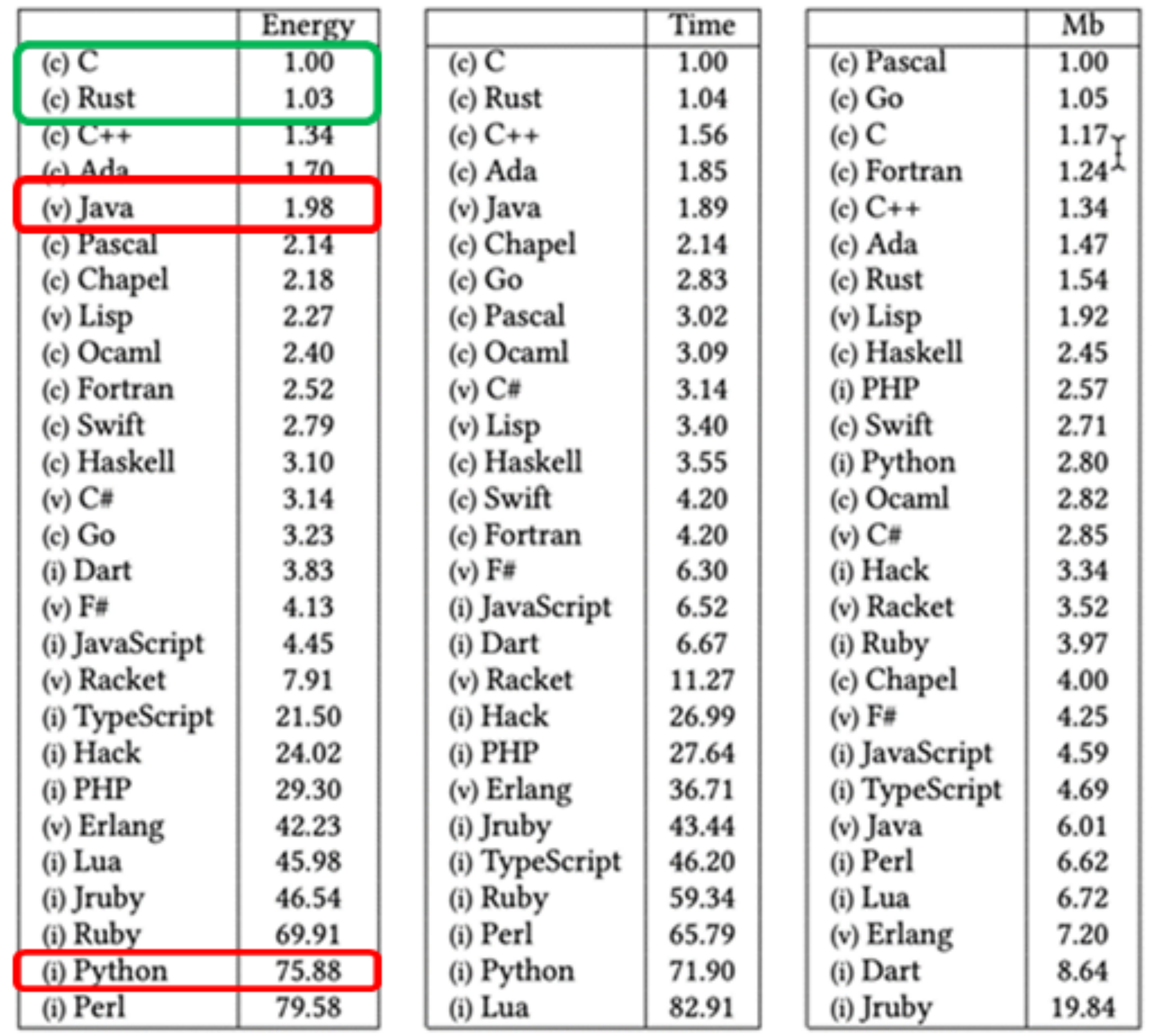
A badly defined pointer-swap could cause a memory leak. Rust's type system disallows this *by fiat*

Example: Sustainability with Rust

An interesting (slightly dated) article out of AWS

Rust is performant, energy efficient *and a whole lot more interesting than many other options*





	Energy
(c) C	1.00
(c) Rust	1.03
(c) C++	1.34
(c) Ada	1.70
(v) Java	1.98
(c) Pascal	2.14
(c) Chapel	2.18
(v) Lisp	2.27
(c) Ocaml	2.40
(c) Fortran	2.52
(c) Swift	2.79
(c) Haskell	3.10
(v) C#	3.14
(c) Go	3.23
(i) Dart	3.83
(v) F#	4.13
(i) JavaScript	4.45
(v) Racket	7.91
(i) TypeScript	21.50
(i) Hack	24.02
(i) PHP	29.30
(v) Erlang	42.23
(i) Lua	45.98
(i) Jruby	46.54
(i) Ruby	69.91
(i) Python	75.88
(i) Perl	79.58

	Time
(c) C	1.00
(c) Rust	1.04
(c) C++	1.56
(c) Ada	1.85
(v) Java	1.89
(c) Chapel	2.14
(c) Go	2.83
(c) Pascal	3.02
(c) Ocaml	3.09
(v) C#	3.14
(v) Lisp	3.40
(c) Haskell	3.55
(c) Swift	4.20
(c) Fortran	4.20
(v) F#	6.30
(i) JavaScript	6.52
(i) Dart	6.67
(v) Racket	11.27
(i) Hack	26.99
(i) PHP	27.64
(v) Erlang	36.71
(i) Jruby	43.44
(i) TypeScript	46.20
(i) Ruby	59.34
(i) Perl	65.79
(i) Python	71.90
(i) Lua	82.91

	Mb
(c) Pascal	1.00
(c) Go	1.05
(c) C	1.17
(c) Fortran	1.24
(c) C++	1.34
(c) Ada	1.47
(c) Rust	1.54
(v) Lisp	1.92
(c) Haskell	2.45
(i) PHP	2.57
(c) Swift	2.71
(i) Python	2.80
(c) Ocaml	2.82
(v) C#	2.85
(i) Hack	3.34
(v) Racket	3.52
(i) Ruby	3.97
(c) Chapel	4.00
(v) F#	4.25
(i) JavaScript	4.59
(i) TypeScript	4.69
(v) Java	6.01
(i) Perl	6.62
(i) Lua	6.72
(v) Erlang	7.20
(i) Dart	8.64
(i) Jruby	19.84

https://aws.amazon.com/cn/blogs/opensource/sustainability-with-rust/

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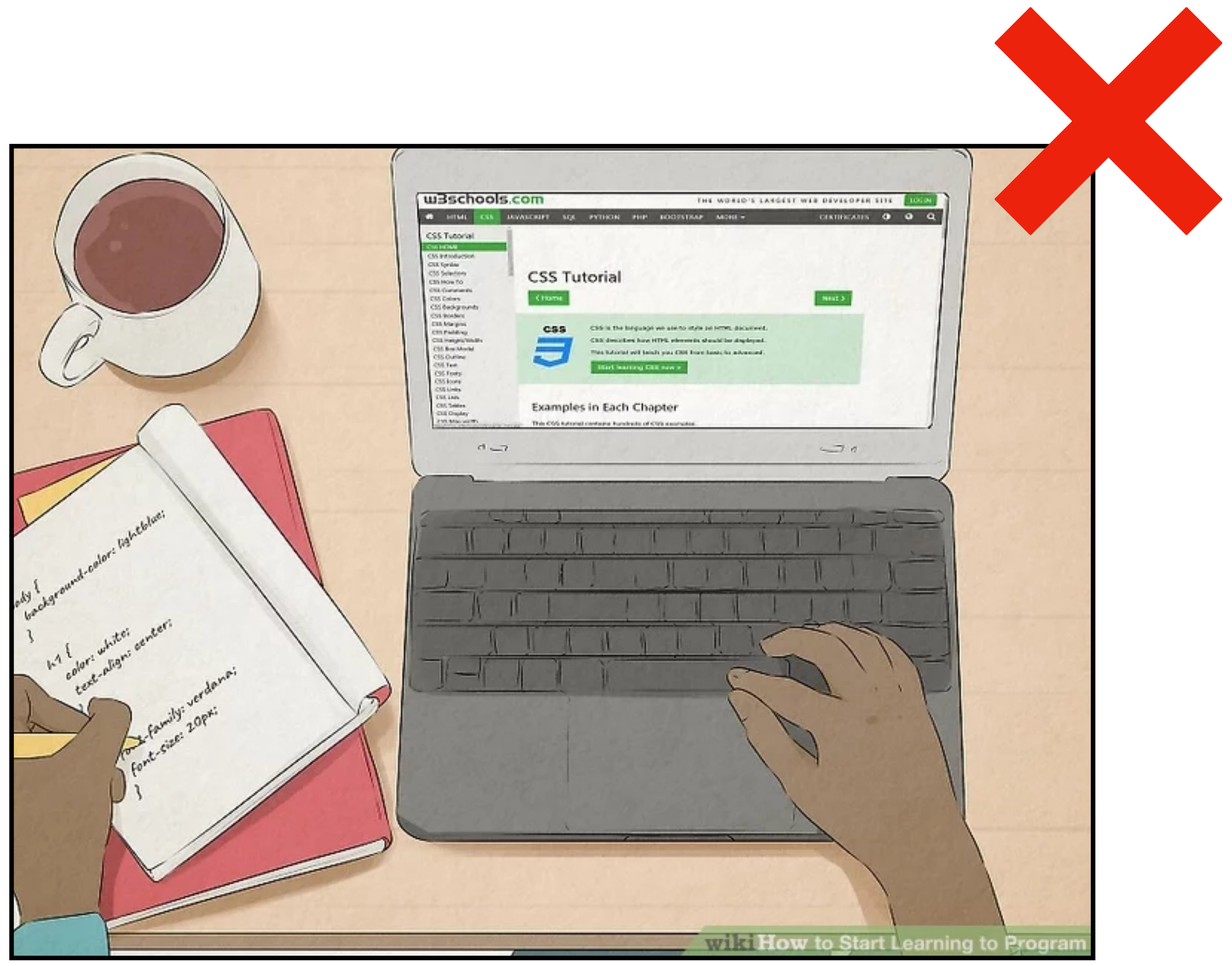

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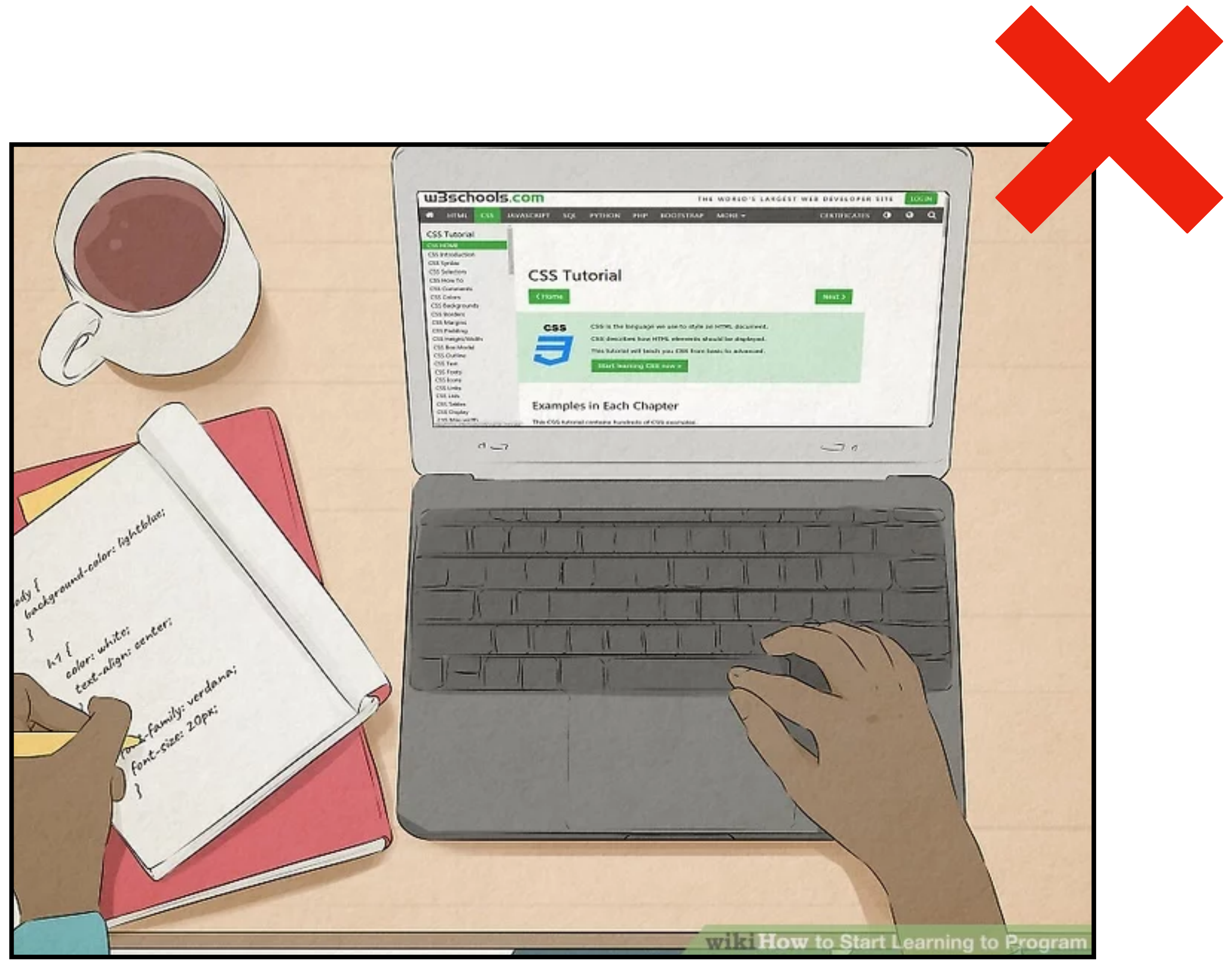

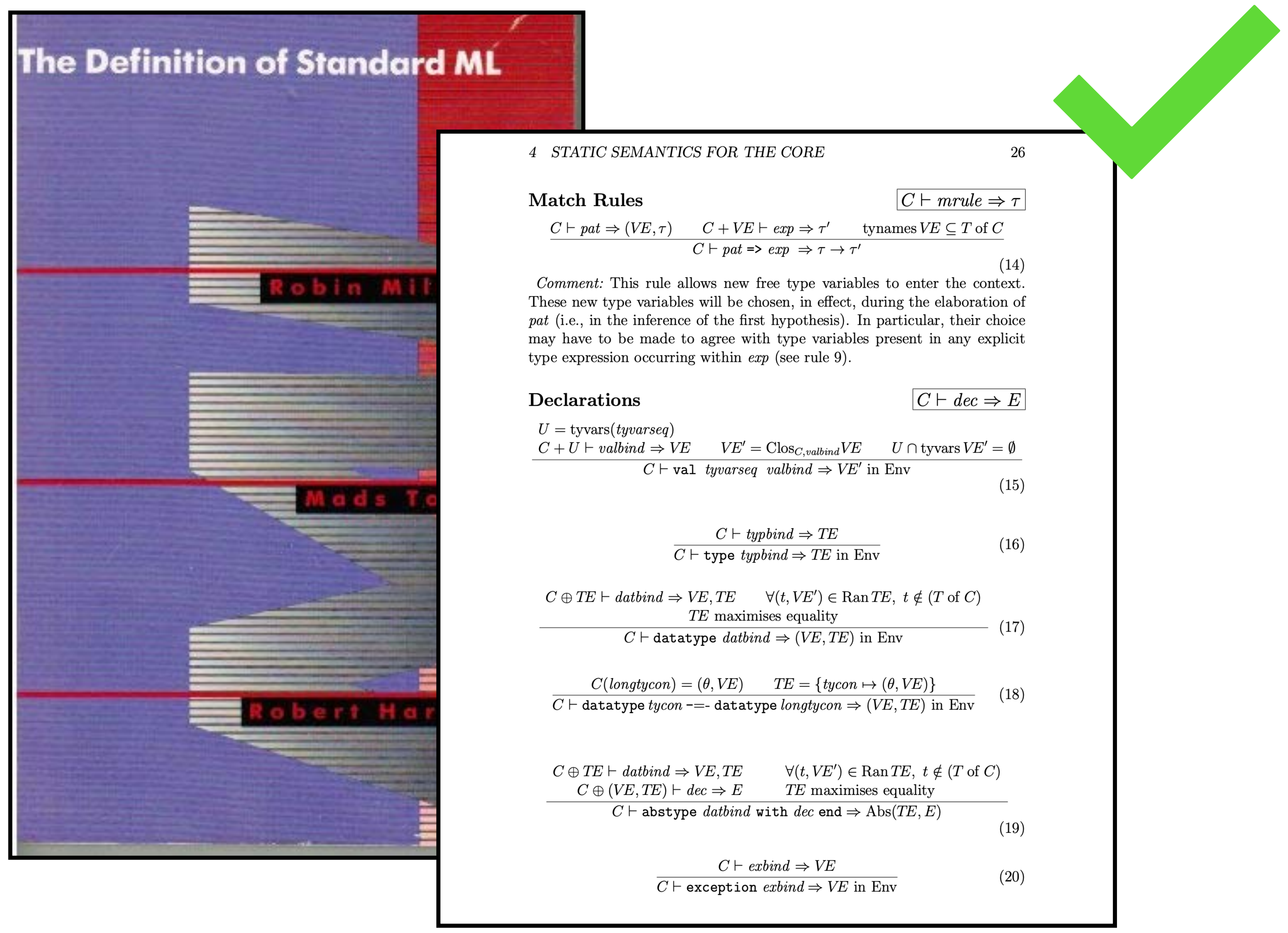
The Definition of Standard ML
Robin Mil
Mads To
Robert Har

4 STATIC SEMANTICS FOR THE CORE 26

Match Rules $\boxed{C \vdash mrule \Rightarrow \tau}$

$$\frac{C \vdash pat \Rightarrow (VE, \tau) \qquad C + VE \vdash exp \Rightarrow \tau' \qquad \text{tynames}\, VE \subseteq T \text{ of } C}{C \vdash pat \texttt{ => } exp \Rightarrow \tau \to \tau'} \quad (14)$$

Comment: This rule allows new free type variables to enter the context. These new type variables will be chosen, in effect, during the elaboration of *pat* (i.e., in the inference of the first hypothesis). In particular, their choice may have to be made to agree with type variables present in any explicit type expression occurring within *exp* (see rule 9).

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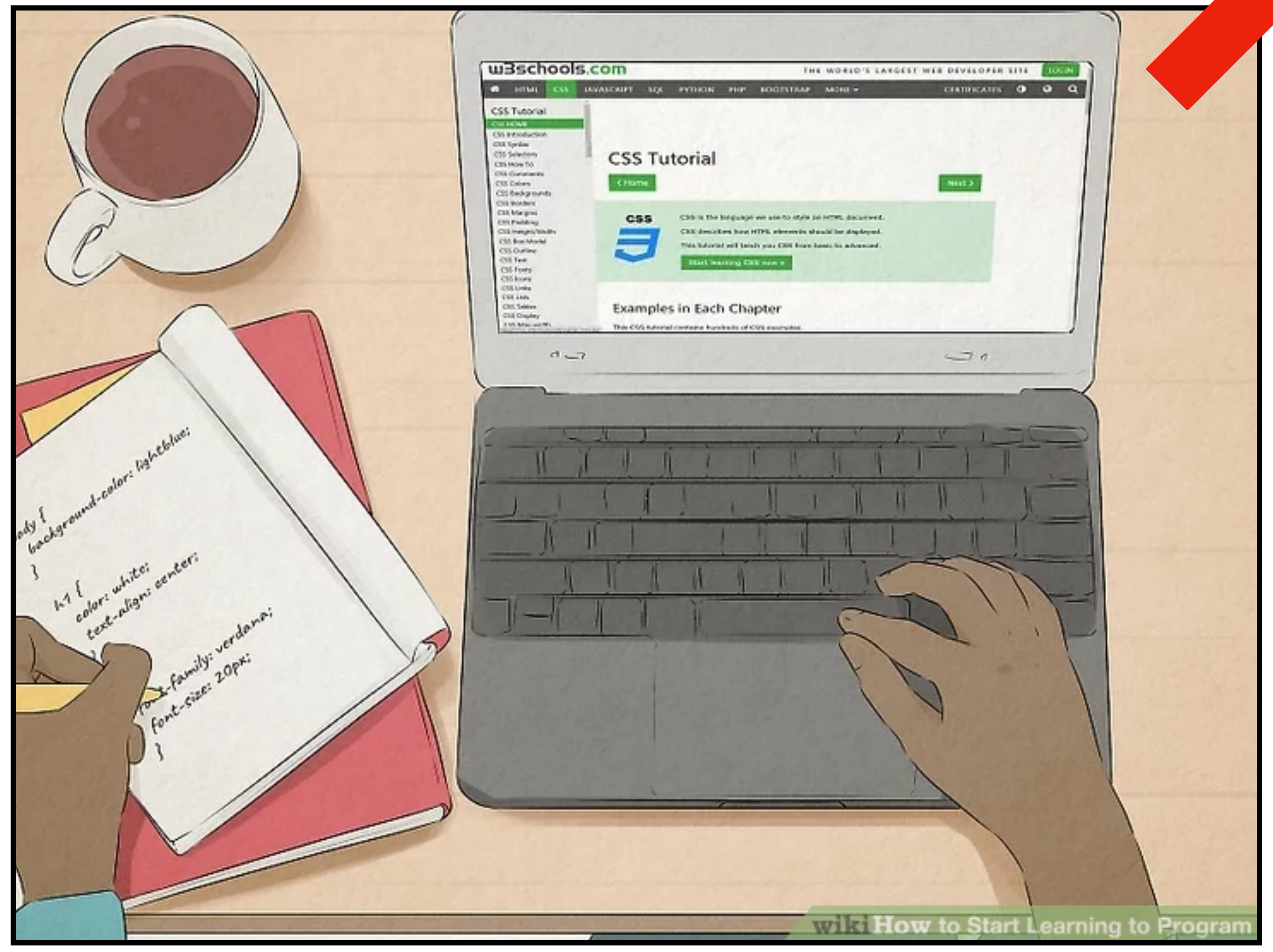

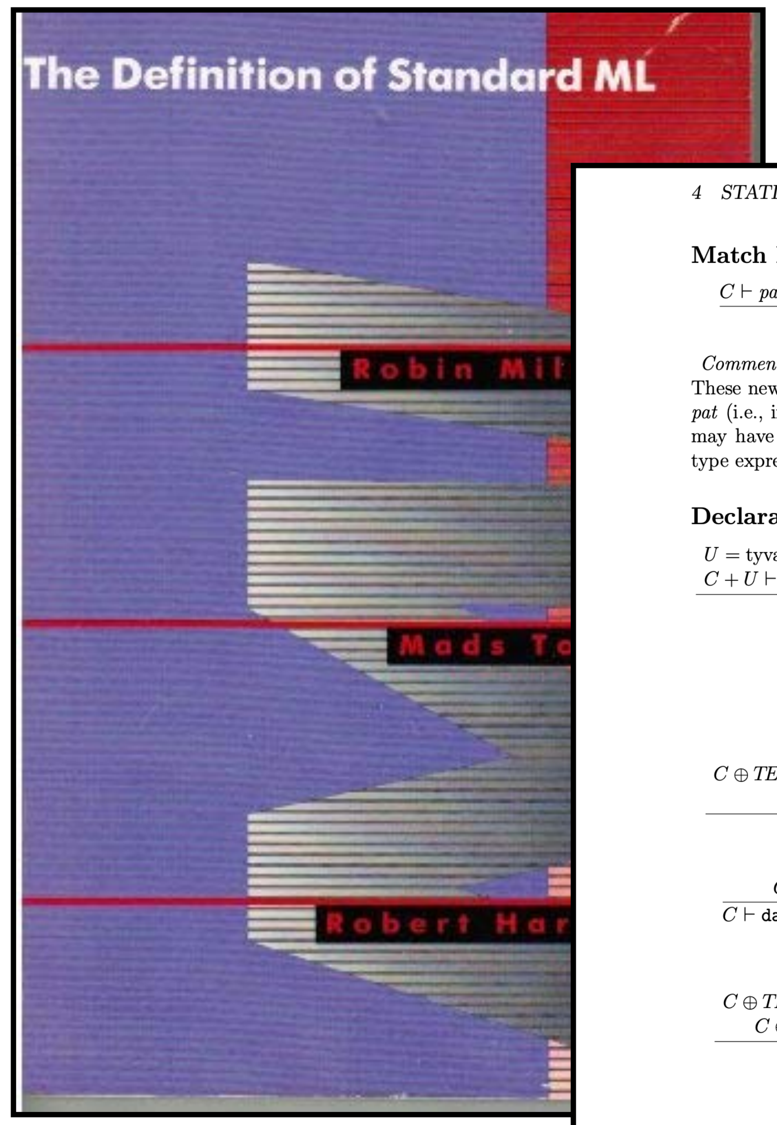

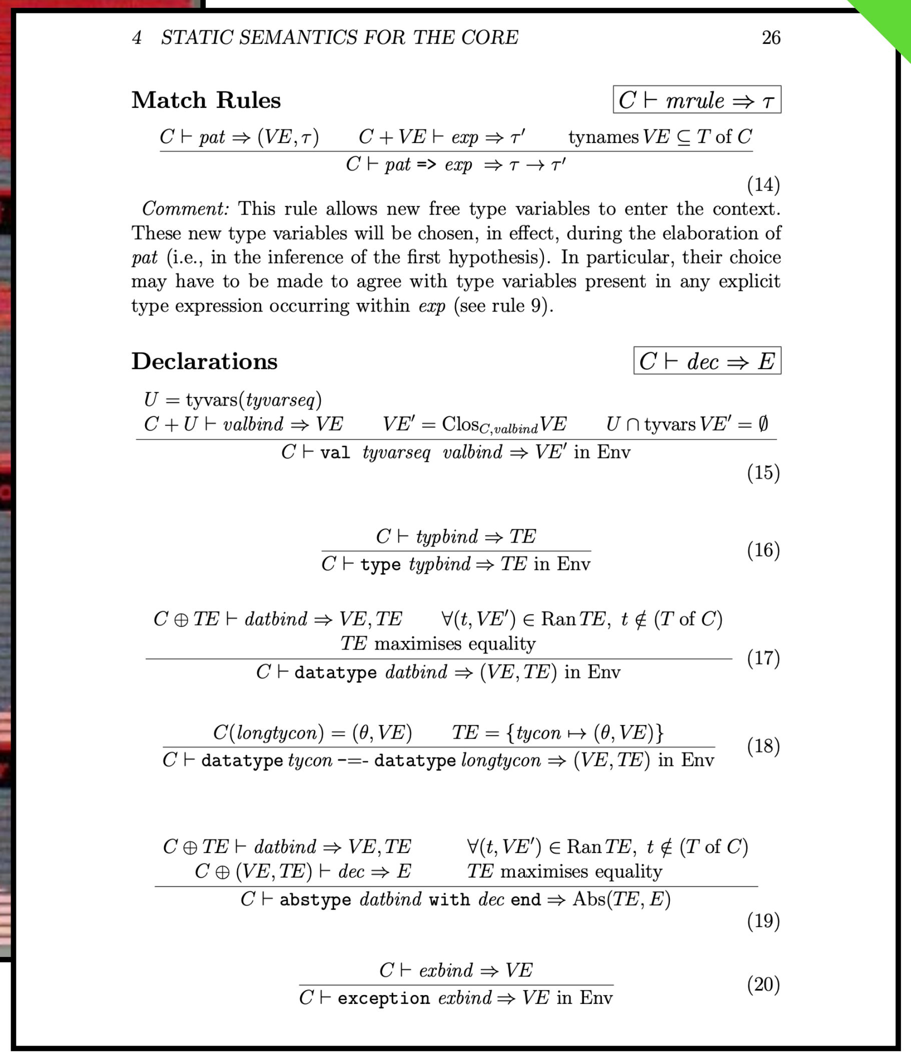
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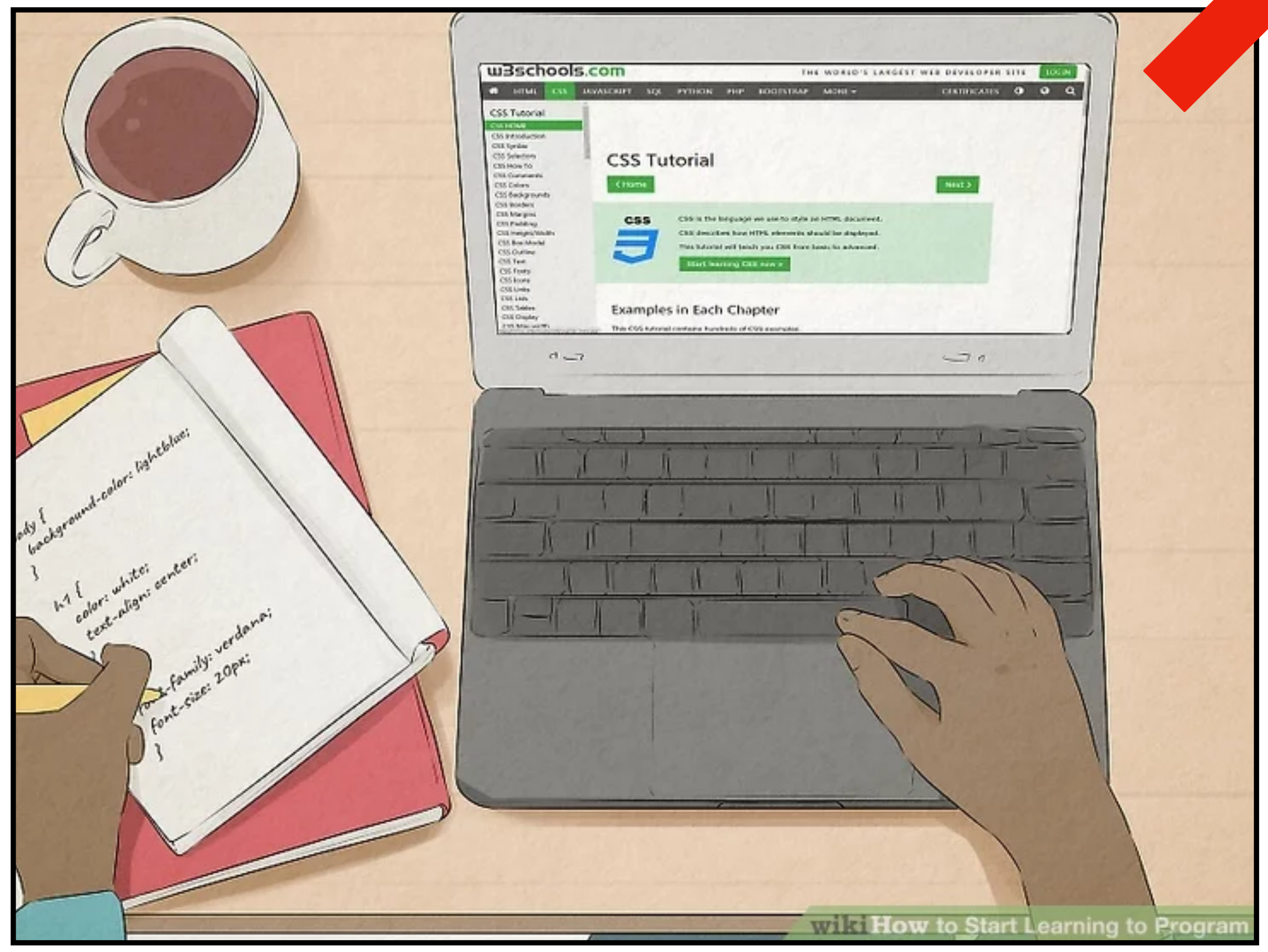
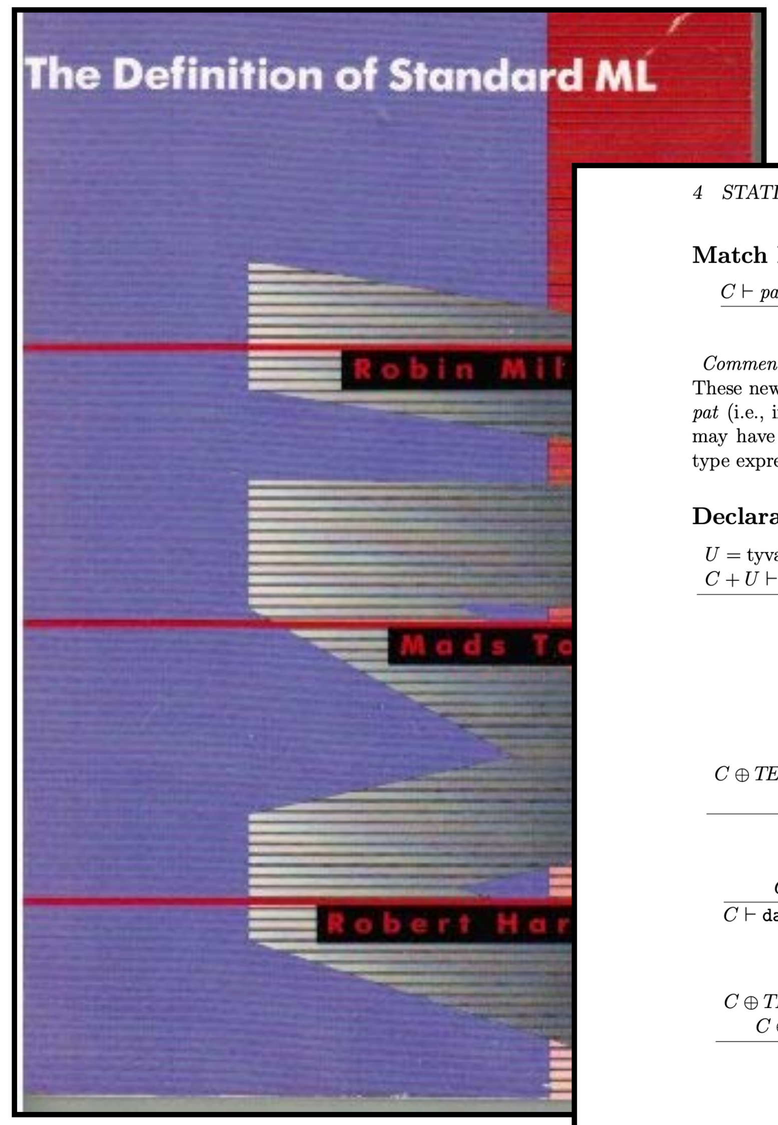
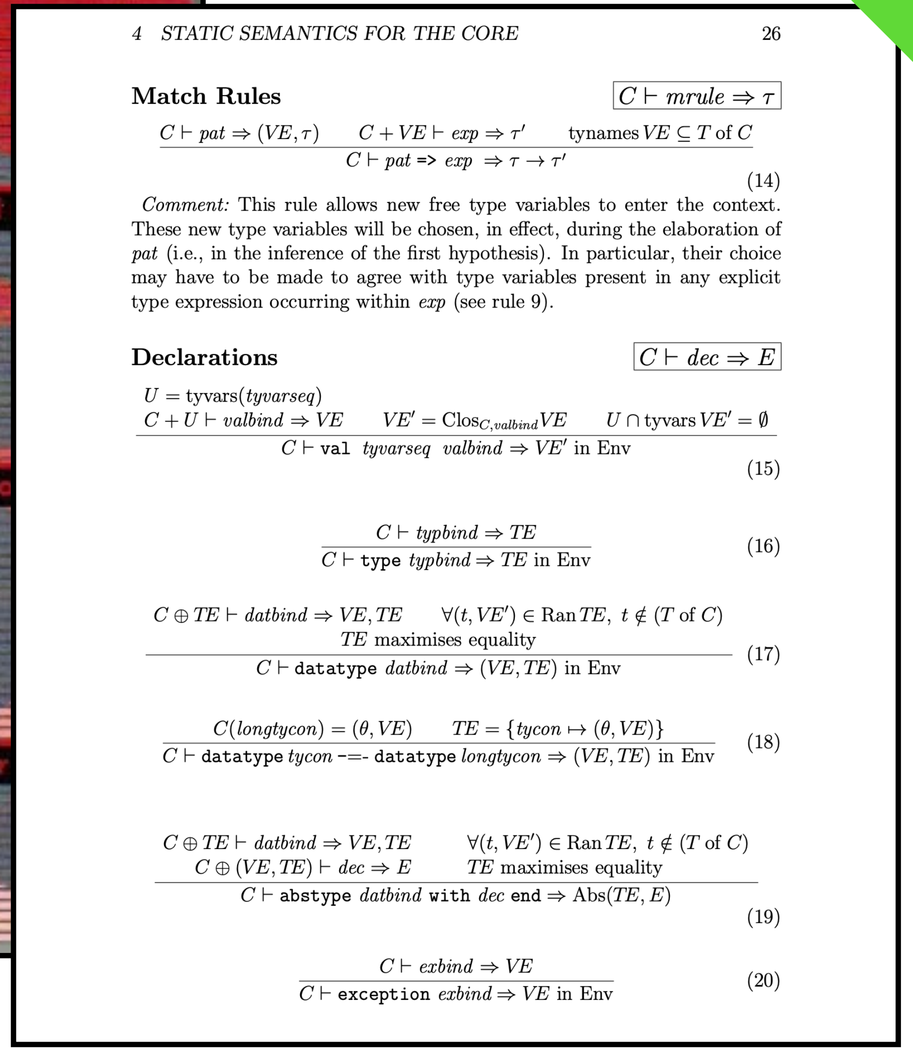
We *will* learn why Rust makes us tackle with the type system, and how it works







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This is exactly the kind of information we need to know to make sure that, e.g., there are no dangling pointers **without actually specifying it** (Rust doesn't work exactly like this)

Workshop:

Install Rust

Set up a Cargo Project

The Task

Follow the in The Rust Programming Language (RPL) on installing **rustup.** If you're using windows I *highly recommend* using WSL. If you finish, then follow the tutorial in RPL called **Hello, Cargo!**

Note: This is how I'll take attendance, so please make sure to talk to me before the end of lecture