Today:
What's this class about???

Welcome to CS450!

High Level Languages

UMass Boston Computer Science

Instructor: Stephen Chang

Spring 2025

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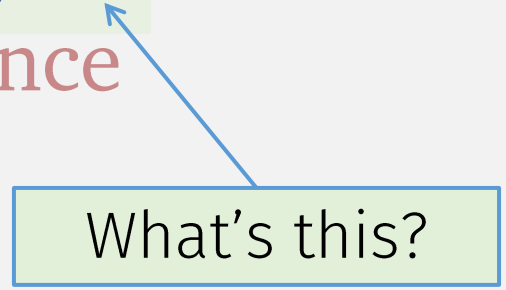
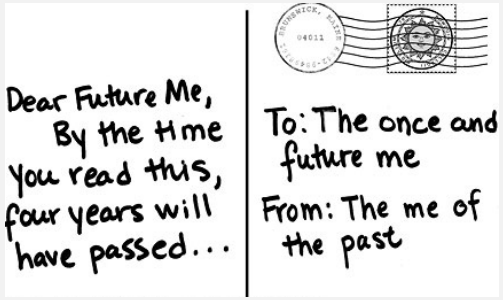


What's a Language?

- A language is for communication
  - With whom?

- A language is used to communicate to:
  - Other people (in a conversation)
  - To yourself (notes)
  - Across time!



From Wikipedia, the free encyclopedia

Language is a structured system of communication that consists of grammar and vocabulary. It is the primary means by which humans convey meaning, both in spoken and written forms,

Human language is characterized by its cultural and historical diversity, with significant variations observed between cultures and across time.

S what is a language

A language is a structured system of communication that enables humans to convey information, thoughts, ideas, and emotions to one another. It is a complex and versatile tool that encompasses various components, such as words, grammar, syntax, semantics, and phonetics, which together allow for the creation and interpretation of meaningful messages.

This is a class about **language**

We will learn to **use language** to <u>communicate</u> (**read, write,** and **speak**) effectively

Welcome to Programming High Level Languages

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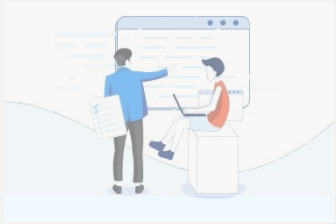
What's this?

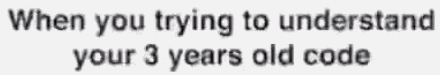
What's a Programming Language?

- A way for **programmers** to <u>communicate</u> …

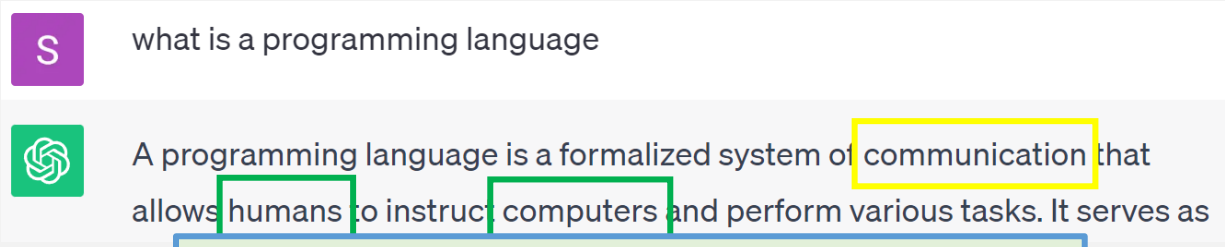
  - … machine instructions (to a computer)
    - i.e., "**programs**"
  - … **ideas** (to another programmer)
    - e.g., **code review,**
    - pull requests



  - … **ideas** (to themselves)
    - **You** are the most frequent reader of your code!



  - … across time!



Programs must be **understandable** by <u>both</u> <u>computers</u> and <u>humans</u>!

"Code is **read much more often than it is written**, so plan accordingly"
--- Raymond Chen

"The ratio of time spent **reading versus writing** is over **10 to 1**. We are constantly reading old code as part of the effort to write new code. … [Therefore,] **making it easy to read makes it easier to write.**"
--- **Robert C. Martin**
<u>Clean Code: Handbook of Agile Software Craftsmanship</u>

Today:
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Today:
This class is about learning to …

- *Use* programming languages … to **communicate** effectively!
  - To **computers:** via **machine instructions**
  - To **humans** (incl yourself): via **reading, writing, speaking!**

Today:
This class is about learning to …

- ~~*Use* programming languages … to **communicate** effectively!~~
  - ~~To computers: via machine instructions~~
  - ~~To humans (incl yourself): via reading, writing, speaking!~~
- *Write* programs!

Today:
This class is about learning to …

- ~~*Use* programming languages … to **communicate** effectively!~~
  - ~~To **computers:** via **machine instructions**~~
  - ~~To **humans** (incl yourself)**:** via **reading, writing, speaking!**~~
- *Write realistic* programs!
  - … that are clear and readable by humans!

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High Level Languages Programming

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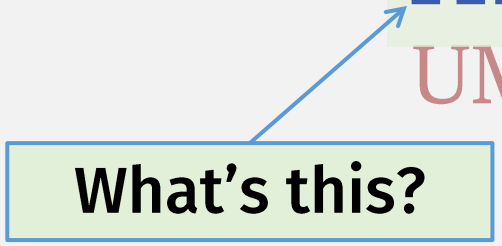


CPU Language

```
0000000 0000 0001 0001 1010 0010 0001 0004 0128
0000010 0000 0016 0000 0028 0000 0010 0000 0020
0000020 0000 0001 0004 0000 0000 0000 0000 0000
0000030 0000 0000 0000 0010 0000 0000 0000 0204
0000040 0004 8384 0084 c7c8 00c8 4748 0048 e8e9
0000050 00e9 6a69 0069 a8a9 00a9 2828 0028 fdfc
0000060 00fc 1819 0019 9898 0098 d9d8 00d8 5857
0000070 0057 7b7a 007a bab9 00b9 3a3c 003c 8888
0000080 8888 8888 8888 8888 288e be88 8888 8888
0000090 3b83 5788 8888 8888 7667 778e 8828 8888
00000a0 d61f 7abd 8818 8888 467c 585f 8814 8188
00000b0 8b06 e8f7 88aa 8388 8b3b 88f3 88bd e988
00000c0 8a18 880c e841 c988 b328 6871 688e 958b
00000d0 a948 5862 5884 7e81 3788 1ab4 5a84 3eec
00000e0 3d86 dcb8 5cbb 8888 8888 8888 8888 8888
00000f0 8888 8888 8888 8888 8888 8888 8888 0000
0000100 0000 0000 0000 0000 0000 0000 0000 0000
*
0000130 0000 0000 0000 0000 0000 0000 0000
000013e
```

Machine code

cpu

Programmers don't write machine code!

Because it's **difficult for humans to understand**

Humans need **"higher level"** languages!

"low level"

<u>Every</u> **programming language** is created only to improve **<u>human</u> communication**

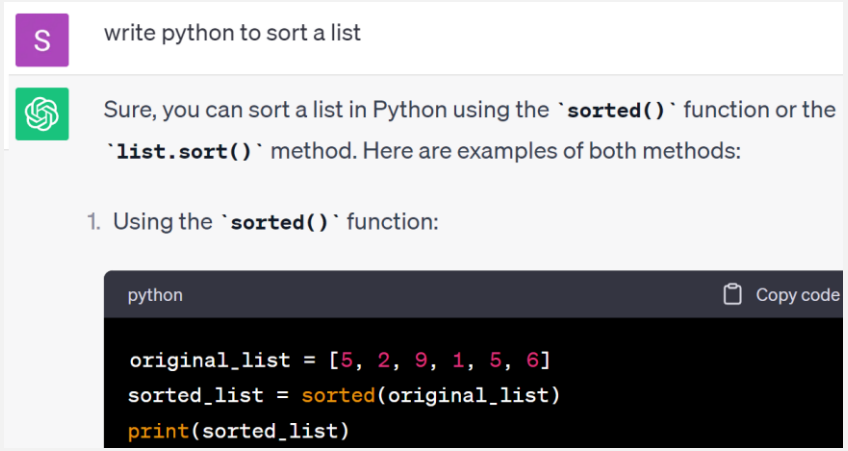
"high" level
(easier for humans
to understand)

English?

What about AI???

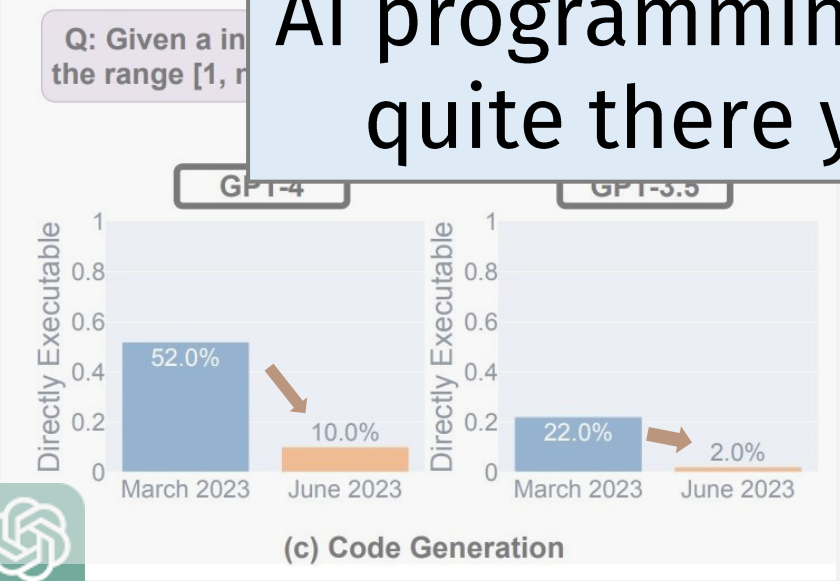
Q: Why don't we just program in English?

A: It's too imprecise



(ChatGPT Getting Worse Over Time?)

Lingjiao Chen†, Matei Zaharia‡, James Zou†



worse

Existing Code

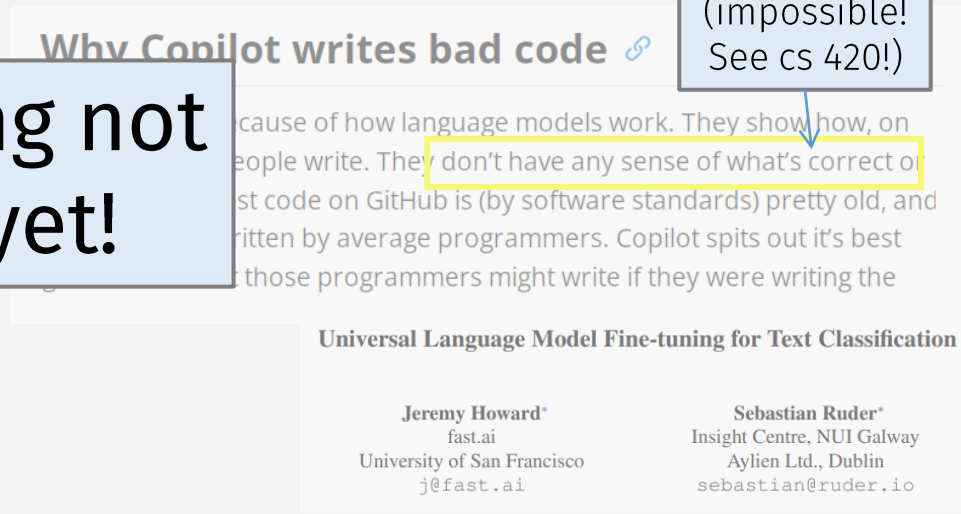
AI

worse quality generated code

"low" level
(runs on cpu)

AI programming not quite there yet!

(impossible! See cs 420!)



“high” level
(easier for humans to understand)

English ☑

Still needed in programs, for:
- Documentation
- Comments
- Specifications

(programs are more than code)

Q: Why don’t we just program in English?

A: It’s too imprecise

Code cannot be ambiguous

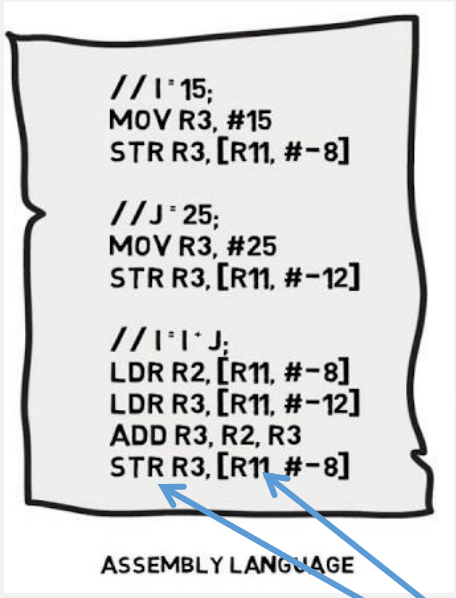
???

Machine code

“low” level
(runs on cpu)

“high” level
(easier for humans to understand)

This is **easier for humans to understand,** but **what about the computer?**



More human-understandable feature:

Language Level:

Assembly Language

Named instructions

Machine code

“low” level
(runs on cpu)

Less performant

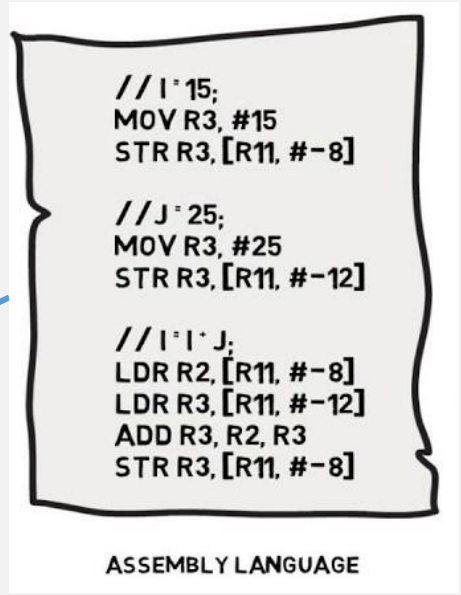
“high” level
(easier for humans to understand)

This is **easier for humans to understand,** but **what about the computer?**

A **higher-level language needs a compiler** (another program!) **to** <u>translate</u> **it to machine code**

(Covered in another course!)

(usually)



<u>Tradeoff</u>: This can introduce inefficiencies

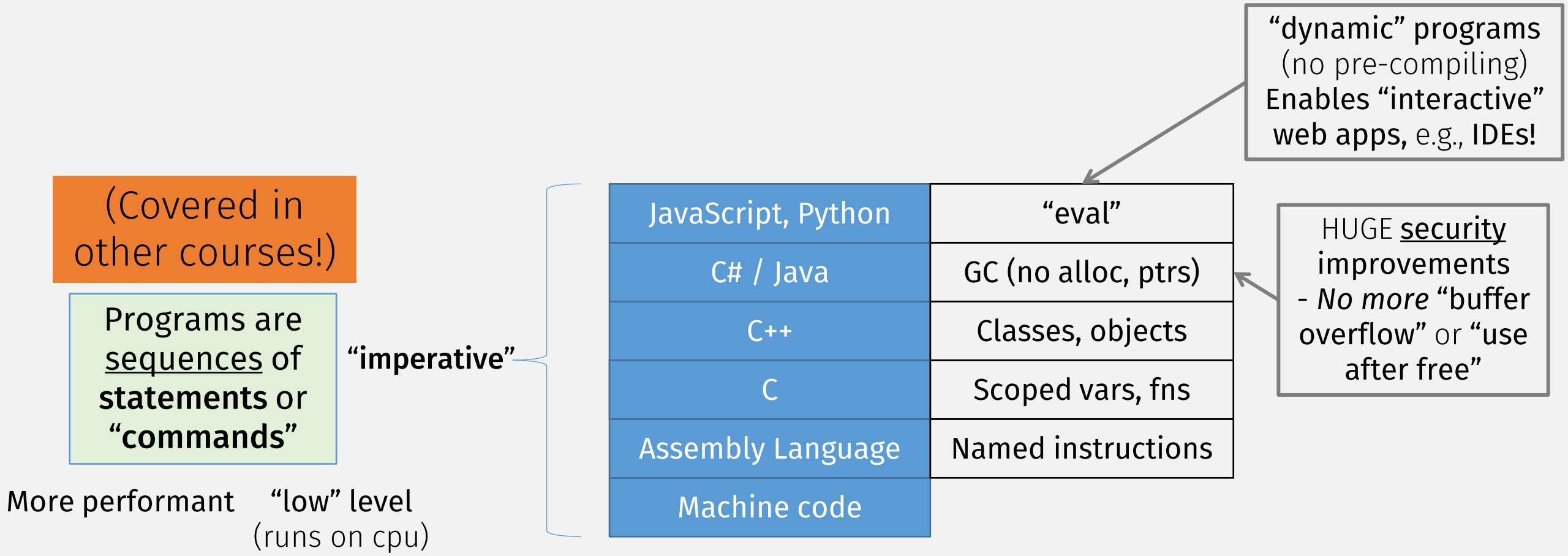
Assembler

More performant

“low” level
(runs on cpu)

Assembly Language	Named instructions
Machine code	

Less performant “high” level
(easier for humans to understand)



More performant “low” level
(runs on cpu)

Less performant

"high" level
(easier for humans
to understand)

"not **imperative?**"

???	???
JavaScript, Python	"eval"
C# / Java	GC (no alloc, ptrs)
C++	Classes, objects
C	Scoped vars, fns
Assembly Language	Named instructions
Machine code	

Programs are sequences of **statements** or "**commands**"

"**imperative**"

More performant

"low" level
(runs on cpu)

Arithmetic

"variable"

"expression"

"function"

$f(x) = (x + 2)$

(but no "return"!)

Function "call"

$f(1) = ???$

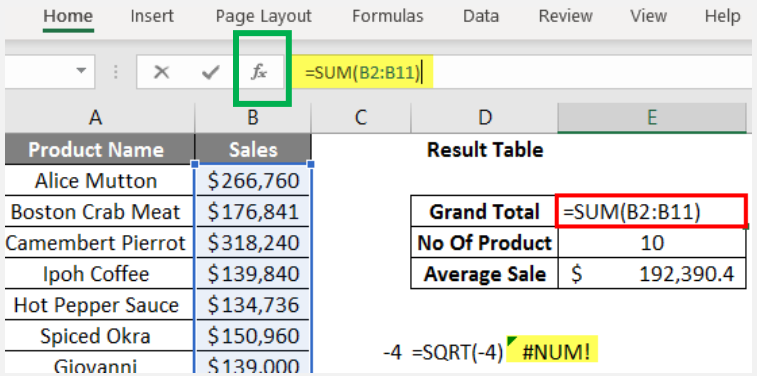
$f(2) = ???$

$f(3) = ???$

Functional languages compute like this (combining arithmetic **expressions**) (instead of sequences of statements)

(main topic in this course)

Is this programming?



Is this a programming language?

YES!

This kind of programming is sometimes called **"declarative"**

"Declare" the computation you want. It's **"high level"** because low-level details are omitted

“high” level
(easier for humans to understand)

“declarative”

Declare computation with **expressions** (compiler decides low level instructions)

Describe computation with exact sequence of **statements**

“imperative”

“low” level
(runs on cpu)

Functional lang (Racket)	Expressions (no stmts)
JavaScript, Python	“eval”
C# / Java	GC (no alloc, ptrs)
C++	Classes, objects
C	Scoped vars, fns
Assembly Language	Named instructions
Machine code	

Lazy Arithmetic

$$f(x, y) = x + 2$$

$$f(\ 1, 2 + 3\ ) = ???$$

Result of this expression
is not needed,
so no need to compute it

Lazy (functional) **languages** (also **mathematical** languages like **R**) **delay computation until it's needed**

(may cover in this course)

“high” level
(easier for humans
to understand)

“declarative”

“imperative”

“low” level
(runs on cpu)

Lazy lang (`Haskell, R`)	Delayed computation
Functional lang (`Racket`)	Expressions (no stmts)
JavaScript, Python	“eval”
C# / Java	GC (no alloc, ptrs)
C++	Classes, objects
C	Scoped vars, fns
Assembly Language	Named instructions
Machine code	

Enables new kinds of programs,
e.g., “tying the knot”

Logic Programming – Even Higher Level

$$f(x) = x + 2$$

Why does this have to be the "input"?

$$f(??) = 3$$
$$f(??) = 4$$

"relational" programming

(may cover in this course)

```
 1 child_fact(oscar,karen,franz).
 2 child_fact(mary,karen,franz).
 3 child_fact(eva,anne,oscar).
 4 child_fact(henry,anne,oscar).
 5 child_fact(isolde,anne,oscar).
 6 child_fact(clyde,mary,oscarb).
 7
 8 child(X,Z,Y) :- child_fact(X,Y,Z).
 9 child(X,Z,Y) :- child_fact(X,Z,Y).
10
11 descendant(X,Y) :- child(X,Y,Z).
12 descendant(X,Y) :- child(X,U,V), descendant(U,Y).
```

Not code, but programs need it for:
- Documentation
- Comments
- Specifications

Potential Problem:
not checked against code,
not guaranteed to match up

English	
Specification langs	Types? pre/post cond? asserts
Markup (html, markdown)	tags
Database (SQL)	queries
Logic Program (Prolog)	relations
Lazy lang (Haskell, R)	Delayed computation
Functional lang (Racket)	Expressions (no stmts)
JavaScript, Python	"eval"
C# / Java	GC (no alloc, ptrs)
C++	Classes, objects
C	Scoped vars, fns
Assembly Language	Named instructions
Machine code	

More "domain specific"

"declarative"

"imperative"

"low" level
(runs on cpu)

NOTE: This hierarchy is *approximate*

"high" level
(easier for humans
to understand)

English	
Specification langs	Types? pre/post cond? asserts
Markup (html, markdown)	tags
Database (SQL)	queries
Logic Program (Prolog)	relations
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Assembly Language	
Machine code	

"declarative"

Declarative languages can have **imperative** features, and vice versa

Can program with statements

```
> (define x 12)
> (set! x (add1 x))
> x
13
```

Can program with expressions

Java Lambda Syntax
Concise
`n -> System.out.print(n)`
Expanded
`(String n) -> System.out.print(n)`
Verbose
`(String n) -> { System.out.print(n); }`

"imperative"

"low" level
(runs on cpu)

Goal: learn to use "high-level" programming **concepts**, not a specific programming language

Today:
This class is about learning to …

- *Use* programming languages to …
  communicate effectively!
  - To **computers:** via **machine instructions**
  - To **humans** (incl yourself)**:** via **reading, writing, speaking!**

  i.e., ***write*** **programs!** (that are **clear** and **readable** **by humans!**)

Today:
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Today:
This class is about learning to …

Part 1

- *Use* **high-level** programming language features to …
  ~~**communicate** effectively!~~
  - ~~To **computers:** via **machine instructions**~~
  - ~~To **humans** (incl yourself)**:** via **reading, writing, speaking!**~~

  i.e., ***write*** **programs!** (that are **clear** and **readable** by humans!)

Redundant!

(Remember: **high-level languages** invented for human communication)

Today:
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Part 1
- *Use* **high-level** programming language features to …
  ~~**communicate effectively!**~~
  - ~~To computers: via machine instructions~~
  - ~~To humans (incl yourself): via reading, writing, speaking!~~

  i.e., *write* programs! (that are clear and readable by humans!)

Part 2
- *Implement a* **high-level** programming language ~~features~~

Today:
This class is about learning to …

Part 1 • *Use* **high-level** programming language features to …
~~**communicate effectively!**~~
- ~~To computers: via machine instructions~~
- ~~To humans (incl yourself): via reading, writing, speaking!~~

helps

i.e., *write* programs! (that are clear and readable by humans!)

use

Part 2 • *Implement* a **high-level** programming language

Course Logistics

All course info available on web site:
https://www.cs.umb.edu/~stchang/cs450/s25

Racket (main programming language for this course)

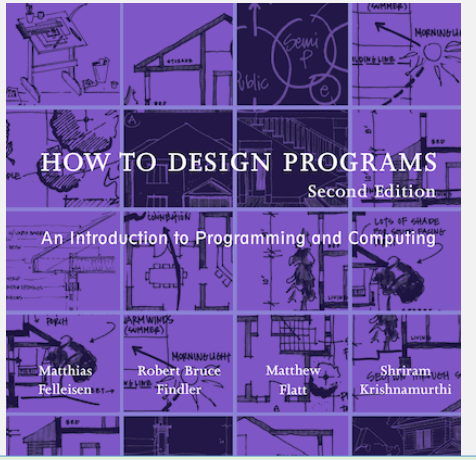
- Primarily “Functional”
- Easy (syntax) to learn
  - (But different than you might be used to!)
- Download at **`racket-lang.org/download`**
  - See hw0
  - Install and be ready to write code in next (Thursday) lecture

And **Practice** / **Improve** Your
Most Valuable Skill:

Learning New Concepts!

(textbook for this course)

How to Design Programs, 2nd ed.



Lessons:

- **Programs** are also for **high-level communication**
- This means that **programs are more than just what the code does**
- Must be **readable and explainable by others**

Every **org / company** has **rules for how to write clean, readable program**

This is our rulebook!

Available free at: `htdp.org`

- Can buy paper copy (make sure it's 2nd ed) if you wish

All course info available on web site:
`https://www.cs.umb.edu/~stchang/cs450/s25`

GitHub

We will use `GitHub` for code management

1. Create an account (free) if you don't have one
2. Install a GitHub client and learn basic commands
3. Tell course staff your account name
   - (fill out pre-class survey if you have not done so!)

All course info available on web site:
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HW 0

- due: (next) **Tuesday 2/4 11am**
  - Create `github` account and learn basics
  - Tell course staff `github` account name (see hw0 details)
  - Install `Racket`
  - "`Hello World`"ish `Racket` programs
  - Be ready to program in class

Other Infrastructure

- Gradescope
  - Submitting HW and grading
- Piazza
  - Non-lecture communication

Grading

- **HW**: 80%
  - Weekly: in/out Tuesday (usually)
  - Approx. 12 assignments
  - Lowest grade dropped
- **Participation**: 20%
  - In-class work, lecture, office hours, Piazza
- No exams

- **A** range: 90-100
- **B** range: 80-90
- **C** range: 70-80
- **D** range: 60-70
- **F**: < 60

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Grading

- **HW**: 80%
  - Weekly: in/out Tuesday (usually)
  - Approx. 12 assignments
  - Lowest grade dropped

Evaluated on a program's:

- **correctness**
  - i.e., test suites
- **readability**
  - Can **someone read and explain** what it does?
- **understanding**
  - Can **you read and/or explain** what it does?

All course info available on web site:
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Late HW

- Is bad …
  - Grades get delayed
  - Can’t discuss solutions
  - You fall behind!

- Late Policy: **3 late days** to use during the semester

HW Collaboration Policy

Allowed

- Discussing HW with classmates (but must cite)
- Using other resources, e.g., youtube, other books, etc.
- Writing up answers on your own, from scratch, in your own words / code

Not Allowed

- Submitting someone else's answer
- It's still someone else's answer if:
  - variables are changed,
  - words are omitted,
  - or sentences rearranged …
- Using sites like Chegg, CourseHero, Bartleby, Study, etc.
- Using AI bots like ChatGPT, Copilot, Claude, DeepSeek, etc.

Honesty Policy

- 1st offense: zero on problem
- 2nd offense: zero on hw, reported to school
- 3rd offense+: F for course

Regret policy

- If you self-report an honesty violation, you'll only receive a zero on the problem and we move on.

All Up to Date Course Info

Survey, Schedule, Office Hours, HWs, …

See course website:

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