600.325/425 Declarative Methods

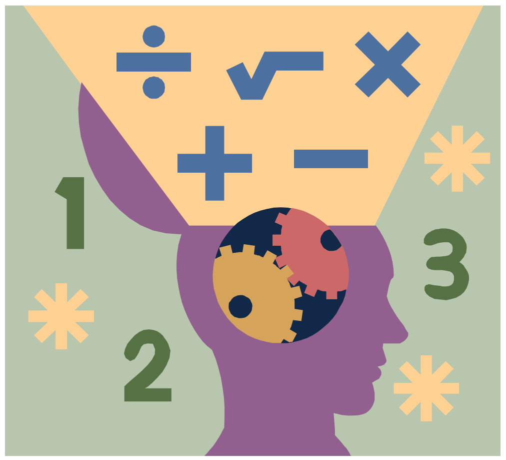
Prof. Jason Eisner

MWF 3-4pm (sometimes 3-4:15)

What is this course about?

- What do you learn in a programming course?
  - How to use a language (e.g., Java) to solve problems
  - How the computer actually executes that language
    - (Why do you need to know this?)
- Ok, this is a programming course
  - We'll survey several languages
  - But they aren't normal languages!

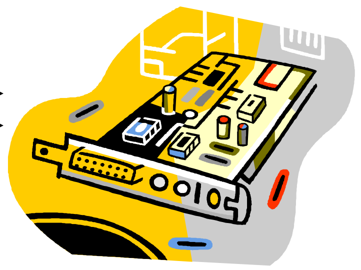
Low-level vs. high-level languages



One common language
Can do anything
(Turing-complete)

Lots of different tasks

Assembler
C
FORTRAN

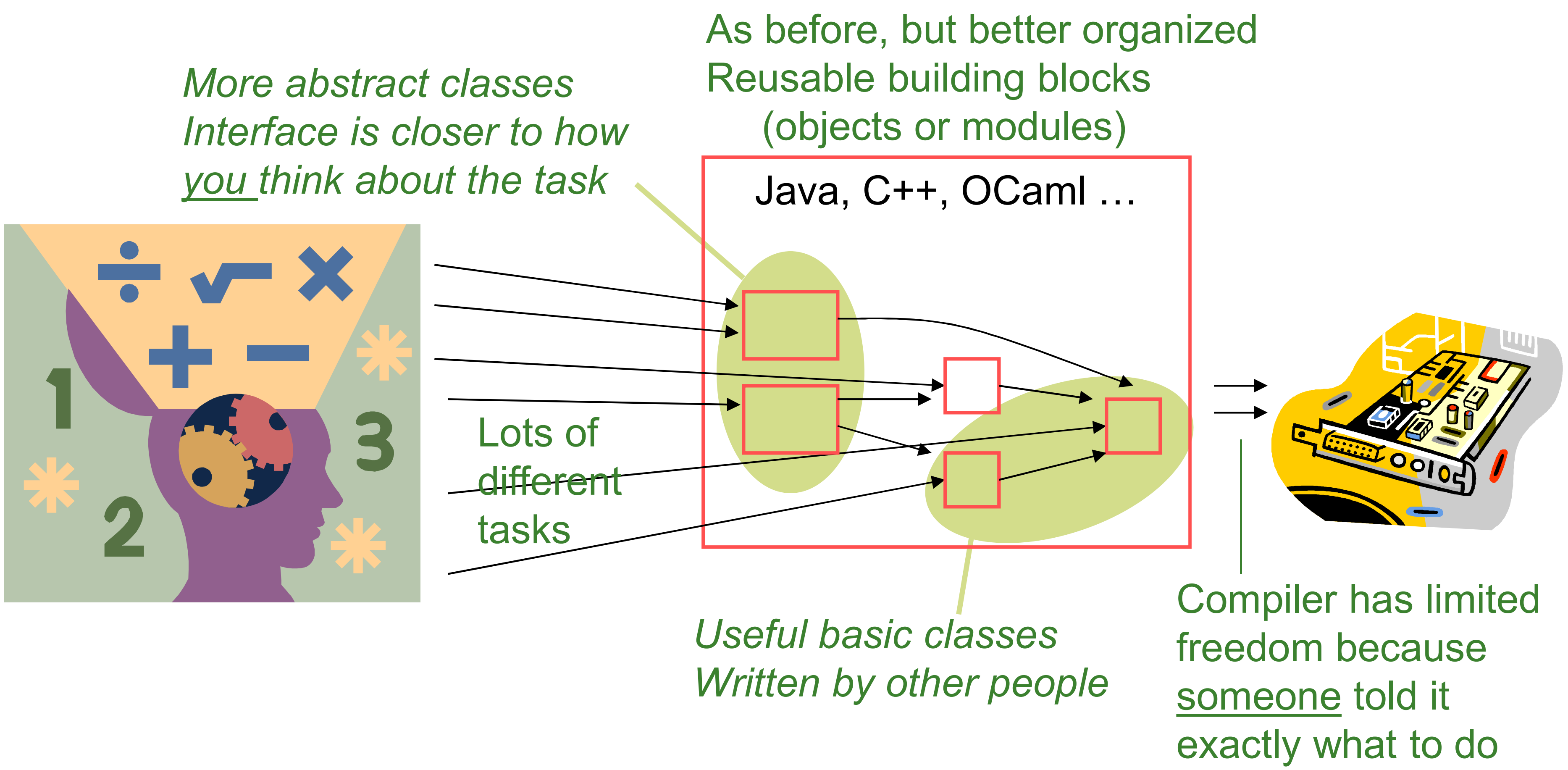


Programmer has freedom to write anything.
Hopefully has a lot of free time, too.

Compiler has limited freedom because you told it exactly what to do

Low-level: Long, detailed programs written by anal-retentive programming gurus

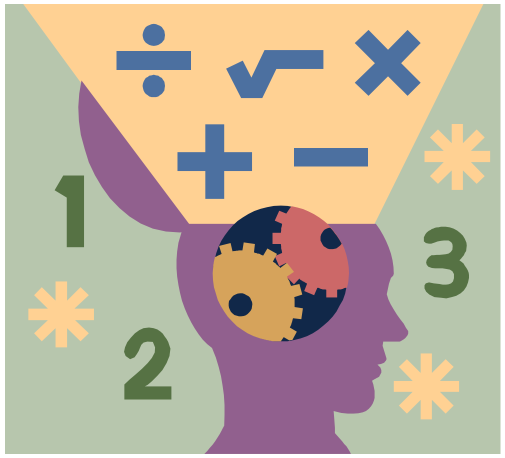
Low-level vs. high-level languages



Building up high-level objects from low-level ones
But language and compiler are still low-level

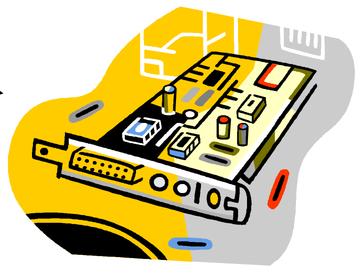
Low-level vs. high-level languages

A higher-level language
that can also do anything
(Turing-complete)



English
and its
obscure
variants

(Hindi,
Chinese,
German,
…)



Boy, wouldn't you like to write **this**
optimizing compiler?
(take 600.465 NLP)
(and 600.463 Algorithms)

Really high level! Programming for the masses!

Low-level vs. high-level languages

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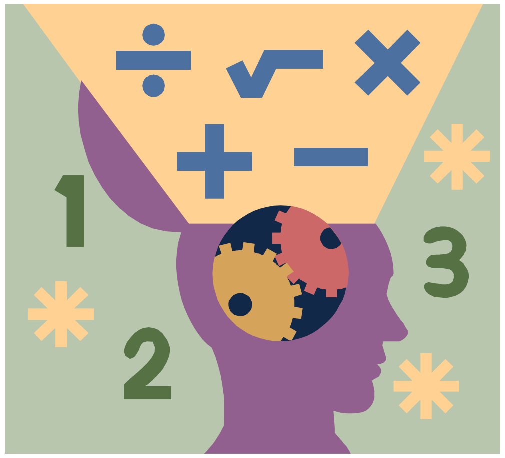
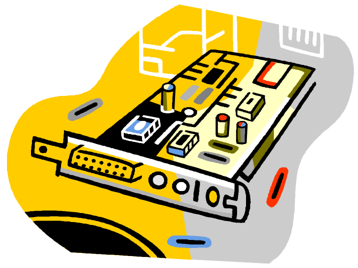


$\longrightarrow$

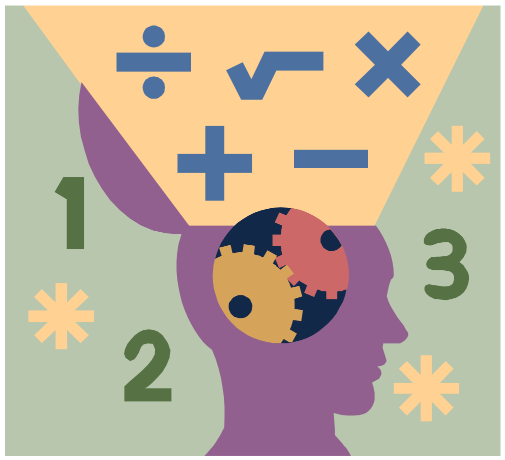
Could we make a formal English-like language?

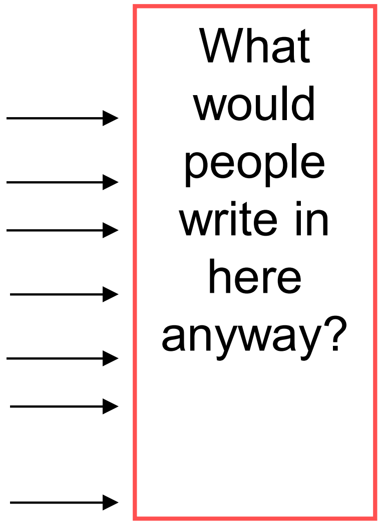


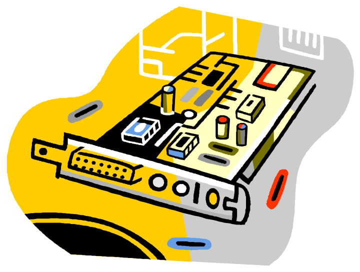
"On each line, replace every third word by x's, then sort the words by length …"
It would have to know an awful lot of concepts (line, word, third, sort, length).
Maybe just make a big library of specialized objects for those concepts?
Some of those objects would need to have pretty powerful methods:
    "Schedule the classes to minimize time conflicts."

Low-level vs. high-level languages

Another language that
can do anything
(Turing-complete)





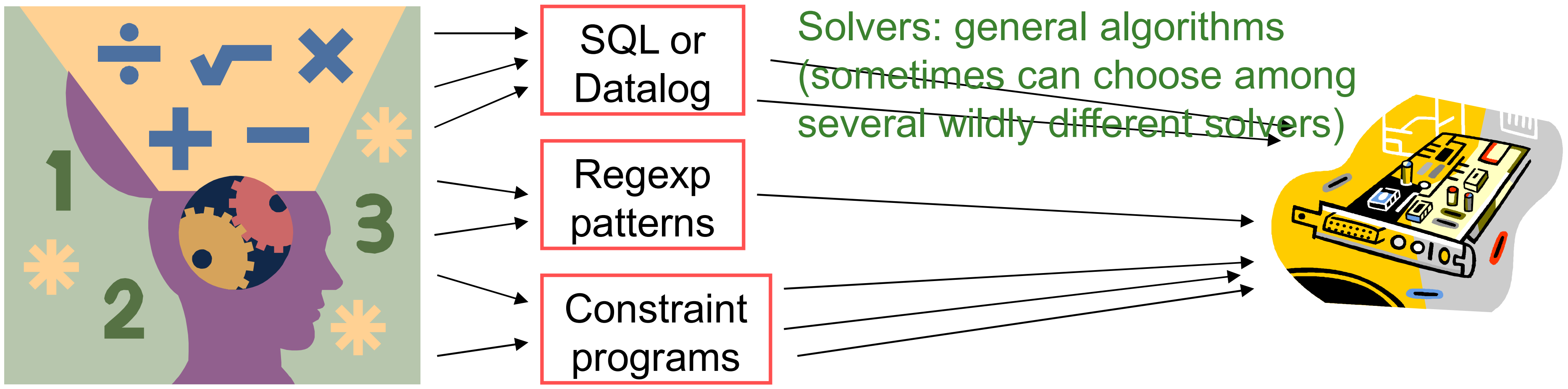


A lot of the same kinds of stuff over and over, actually
So maybe it ***is*** good to build some powerful, general, reusable objects to handle cases that are either ***common*** or ***hard***
Then you don't waste your time doing the same kind of thing again & again
And you don't waste your time figuring out how to do something new & hard

Low-level vs. high-level languages

Several specialized
high-level languages
"Tools for the job"

Solvers: general algorithms
(sometimes can choose among
several wildly different solvers)



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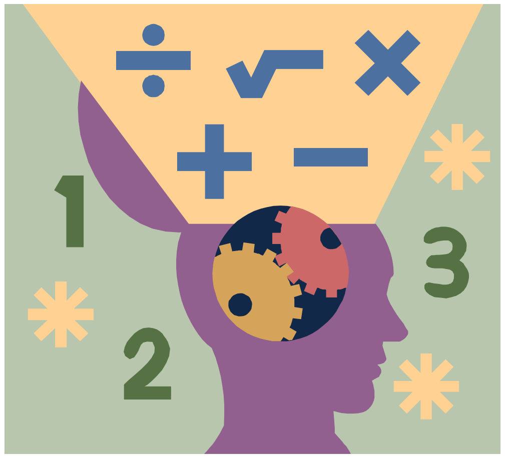
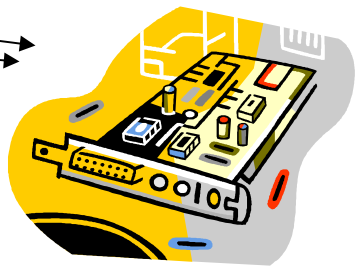


SQL or Datalog

Regexp patterns

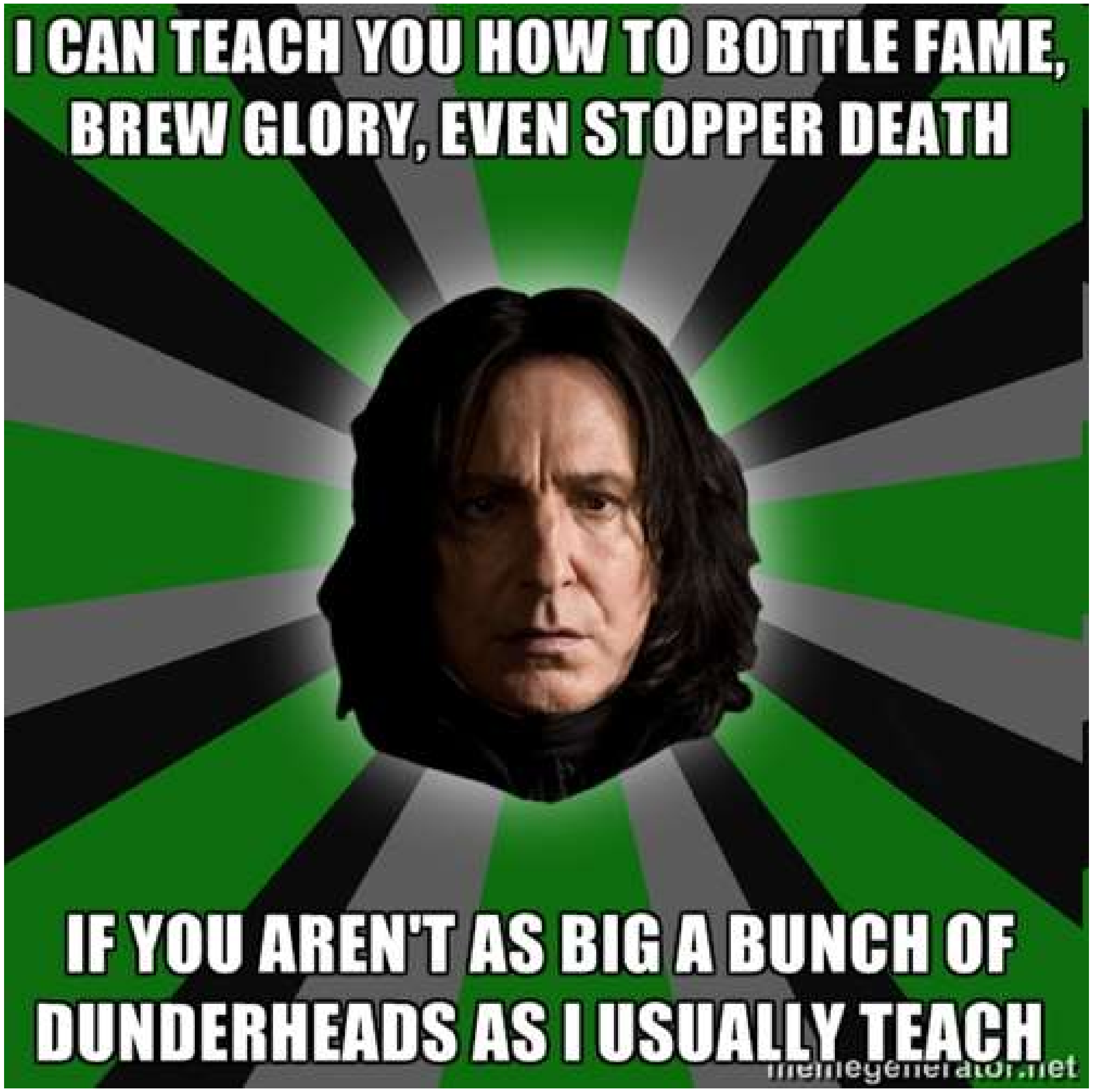
Constraint programs

Solvers: general algorithms



To tell the database about your problem, use SQL (standard query language). More expressive than calling a database method!

Query optimization – might even compile your query into machine code before running it


I CAN TEACH YOU HOW TO BOTTLE FAME, BREW GLORY, EVEN STOPPER DEATH
IF YOU AREN'T AS BIG A BUNCH OF DUNDERHEADS AS I USUALLY TEACH
memegenerator.net

Structure of this course

- **Intro material**
  - What are languages? What do they look like?
  - What's a declarative language? What's a solver?
  - Encoding a problem in a language
  - Reducing one language to another; NP-hardness
- **Several actual languages. For each:**
  - **Week 1:** How does this language let me encode interesting problems?
  - **Homework:** Encode a real problem and run a solver.
  - **Week 2:** What strategies does the solver use to solve arbitrary problems written in the language?
- **Project of your choice (for 425 students)**