

Before we start

We are committed to fostering a learning environment for this course that supports a **diversity of thoughts, perspectives and experiences, and respects your identities** (including race, ethnicity, heritage, gender, sex, class, sexuality, religion, ability, age, educational background, etc.). Our goal is to create a diverse and inclusive learning environment where all students feel comfortable and can thrive.

OPHD at (858) 534-8298, ophd@ucsd.edu, <http://ophd.ucsd.edu>.

Counseling and Psychological Services (**CAPS**) at 858 5343755 or <http://caps.ucsd.edu>

CARE at Sexual Assault Resource Center at 858 5345793 sarc@ucsd.edu <http://care.ucsd.edu>

Financial aid resources, the possibility of emergency grant funding, and off-campus housing referral resources are available. See CAPS and your college dean.

If you or someone you know is suffering from **food and/or housing insecurities** the Triton Food Pantry (in the old Student Center), <https://www.facebook.com/tritonfoodpantry/> is free and anonymous, and includes produce.

CSE 105

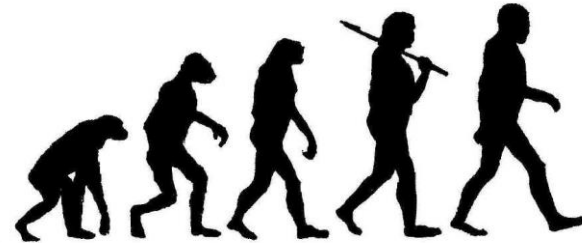
THEORY OF COMPUTATION

Spring 2018

<http://cseweb.ucsd.edu/classes/sp18/cse105-ab/>

Theory of computability

KNOW
LIMITS



Introductions



Clickers

Frequency: **BB**

To change your remote frequency

1. Press and hold power button until flashing
2. Enter two-letter code
3. Checkmark / green light indicates success

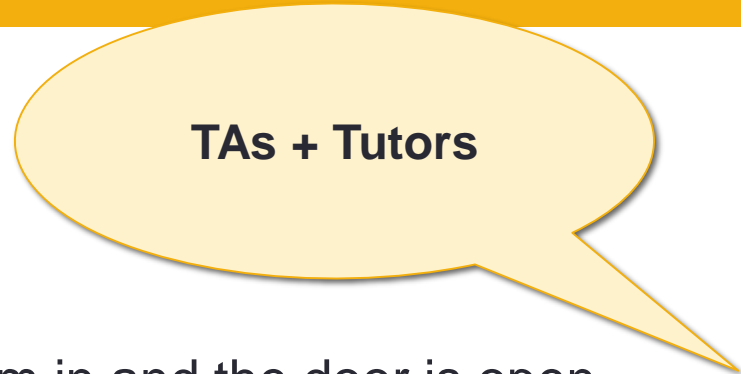
Favorite place to study / work

- A. CSE basement labs / lobbies
- B. Geisel library
- C. Home
- D. Outside (@ the beach?)
- E. Somewhere else



**Why use
clickers?**

About the team



"Minnes" *rhymes with* Guinness

CSE 4206: office hours + come by anytime I'm in and the door is open.

Best way to get in touch is via Piazza

- Public post: question about class policy, notes, etc.
- Private post: question about your HW submission, grading, special circumstances.

Website: cseweb.ucsd.edu/~minnes

Email: minnes@eng.ucsd.edu

Ongoing theory + education research: read more on my website

Logistics

Weekly activities:

Pre-class reading + Class + Review Quiz + Individual HW + Discussion section + Group HW

Individual HW: no collaboration; mostly short-answer

Group HW: work with up to two others, builds on Individual HW; mostly open-ended

Discussion sections: Wednesdays; can attend any section

Exams: **Wednesday** April 25, in class

Wednesday May 23, in class

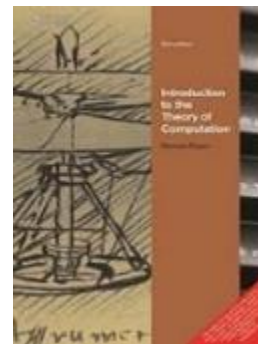
Final Exam **Saturday** June 9 8:00am – 10:59am

No makeup exams

Gradescope: Homework submission, exam return, interim reports

Piazza: announcements and Q&A, homework solutions

Office hours: drop-in (on Google calendar) + one-on-one (on Piazza)



How to excel

- Prepare ahead of class
 - Read assigned sections, read homework questions
- Engage in class
 - **Discuss questions with your neighbors**, look for (counter)examples
 - Go over wrong choices too!
- Reinforce after class
 - Briefly summarize what you learned
- Start homework early and **work in a group**
 - Tackle problems together: brainstorm, plan, and solve together
- Seek help and seek to help others, with integrity



Learning
How to Learn

How to excel with integrity

It's an integrity violation to...

- Click in for someone who is absent
- Sign discussion attendance sheet for someone who is absent
- Ask others to give you specific HW or review quiz or test answers
- Share your answers on HW or review quiz or test
- Work on HW with anyone other than your HW partners
- Search the internet or other resources not provided for the class for HW solutions or help
- Share answers or notes while taking an exam

This not a complete list ... you are responsible for knowing and following the guidelines *Academic integrity violations will be taken seriously and reported immediately*

About this class: Academic integrity

You are working on a homework question with your group members and are stuck on a question. You run into a friend who solved the problem already and shows you her solution. You look at it, but put it away before continuing the group conversation. Is this acceptable?

- A. Yes
- B. No

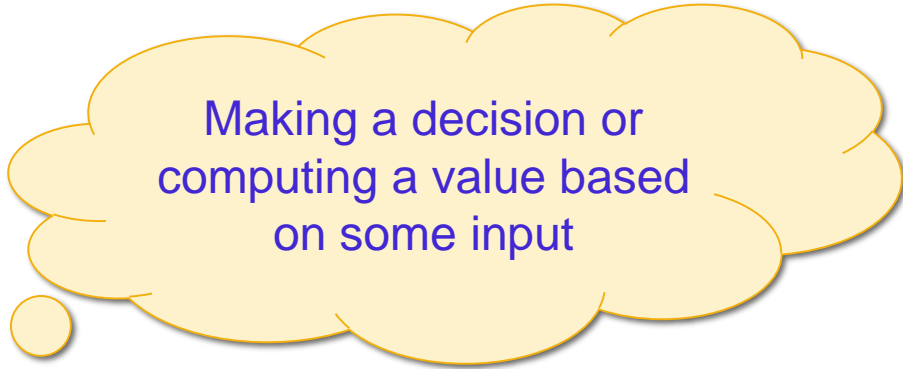
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CSE 105's big questions

- What problems are computers capable of solving?
- What resources are needed to solve a problem?
- Are some problems harder than others?

A large, light yellow thought bubble with a dark yellow outline. Inside the bubble, the text "Making a decision or computing a value based on some input" is written in a dark blue font. Three smaller circles of the same color are connected to the main bubble by thin lines, leading to a rectangular box at the bottom left.

Making a decision or
computing a value based
on some input

A light yellow rectangular box with a dark yellow border. Inside the box, the text "'Problem'?" is written in a bold black font.

"Problem"?

Computational problems

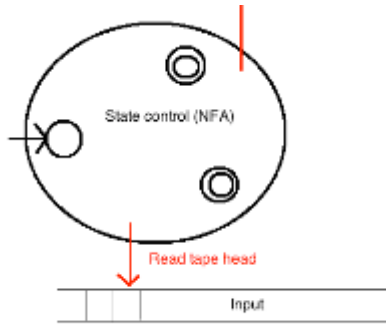
- Find a file on your computer
- Determine if your code will compile
- Find a run-time error in your code
- Certify that your system is un-hackable

Search / input
 \ structure

Which of these is hardest?

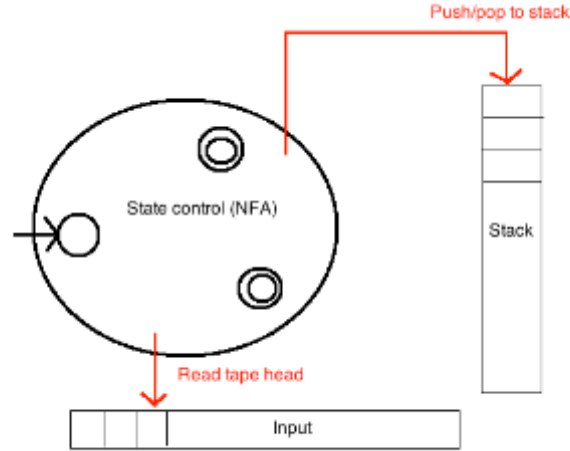
Definitions?

Hardest = uses more resources



Finite automata

2-3wk.



Pushdown automata

2 ~ k



Turing machine

rest

Easy
to compute



Model

- Input: string
- Output: yes/no

When do we output yes?

For input strings that match a specific pattern.

Vocabulary review

From CSE20, etc. Sipser p. 14

- $\{ a, b, c, d, e \}$ The **set** whose elements are a, b, c, d, e
- $| ababab | = 6$ The **length** of the string ababab is 6
- $| \{ a, b, c, d, e \} | = 5$ The **size** of the set $\{ a, b, c, d, e \}$ is 5

$$| \{ a, b, c, d, e, \underline{a} \} | = 5$$

set

New vocabulary

Sipser p. 14

- $\{ a, b \}^*$ The set of finite strings over the symbols a, b
 - Includes empty string ϵ
 - Includes a, aa, aaa
 - Includes b, bb, bbb
 - Includes $ab, ababab, aaaaaaabb$
 - Does **not** include infinite sequences of a 's and b 's
 - Has **infinitely many** different elements
- **Alphabet** Nonempty set of symbols
- **String** over alphabet Σ , Element of Σ^*
- **Language** over alphabet Σ , Subset of Σ^*

Simplest computations / patterns

- Text processing

 - grep, regexp

- Tokenizing

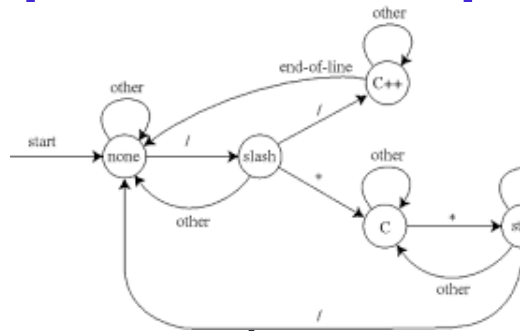
- Natural language processing

- Hardware design

 - Moore machines, Mealy machines: CSE 140

- Controllers / Robots

 - SPIS!



1: 0.N2:s, 0.V3:INF
2: 0.N2:s:p
3: 2.V3:P3:s, 1.N2:p
4: 2.V3:PP, 0.A0
5: 2o.V3:PRET

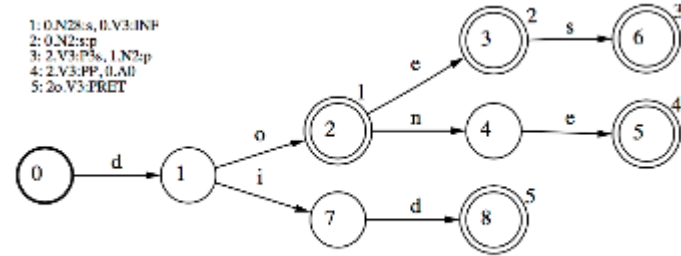
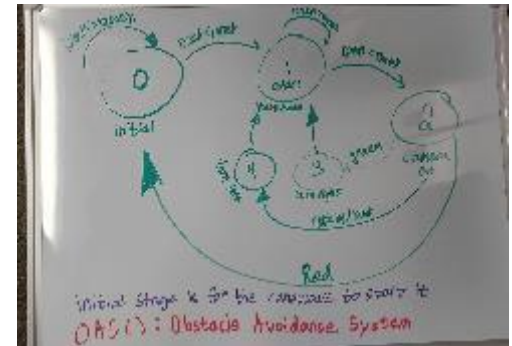


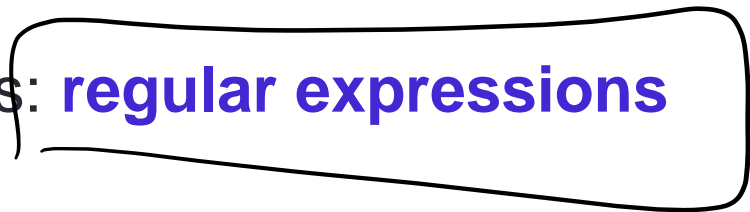
Fig. 1. Representation of dictionaries by automata.



Syntax for describing languages

How do we describe a language?

- List it ... if it's a finite set
- Describe condition for membership ... but can get complicated
- Recursive descriptions of elements: **regular expressions**



Regular expression

Sipser 1.52 p. 64

R is a **regular expression** over the alphabet Σ if

1. $R = a$, where $a \in \Sigma$

2. $R = \varepsilon$

3. $R = \emptyset$

Basis Steps

4. $R = (R_1 \cup R_2)$, where R_1, R_2 are themselves regular expressions

5. $R = (R_1 \circ R_2)$, where R_1, R_2 are themselves regular expressions

6. (R_1^*) , where R_1 is a regular expression.

Recursive Steps

Σ is shorthand for $(0 \cup 1)$ if $\Sigma = \{0, 1\}$, Parentheses may be omitted, R^+ means RR^* , R^k means R concatenated with itself k times

Regular expression

Sipser 1.52 p. 64

Which languages are described by each of these regular expressions?

- $L(R)$
1. $R = \underline{a}$, where $a \in \Sigma$ $\sim L(R) = \{a\}$
 2. $R = \underline{\varepsilon}$ $L(R) = \{\varepsilon\}$
 3. $R = \underline{\emptyset}$ $L(R) = \emptyset$
 4. $R = (R_1 \cup R_2)$ $L(R) = L(R_1) \cup L(R_2)$
 5. $R = (R_1 \circ R_2)$ $L(R) = L(R_1) \circ L(R_2)$
 6. (R_1^*) $L(R_1^*) = L(R_1)^*$

Examples

$\Sigma = \{0,1\}$

or

1. $R = a$, where $a \in \Sigma$
2. $R = \varepsilon$
3. $R = \emptyset$
4. $R = (R_1 \cup R_2)$
5. $R = (R_1 \circ R_2)$
6. (R_1^*)

• $L(\underline{(0 \cup 1)} \cup 1) = \{0,1\} \cup \{1\} = \{0,1\}$

• $L((\underline{\Sigma\Sigma\Sigma\Sigma})^*) = \{0000, 0001, 0010, 0011, \dots\}^*$
 $= \{w \mid |w| = 4k, k > 0\}$

• $L(\underline{\underline{1^*00}}) = \{ \text{FILL IN AS EXERCISE} \}$
Not 11110

Regular expressions in practice

- **Compilers:** first phase of compiling transforms Strings to Tokens **keywords, operators, identifiers, literals**
 - One regular expression for each token type
- **Other software tools:** grep, Perl, Python, Java, Ruby, ...

For next time

- Start Individual Homework 0 **due Saturday**
 - Set up course tools: *Gradescope*, Piazza
 - Read all the questions + relevant examples in the book
 - Start working 😊
 - *Review CSE 20 / Math 109 / CSE 21 / Sipser Ch 0 as needed.*
- Discussion sections Wednesdays
 - Review lecture material and Chapter 0.

Pre class-reading for Wednesday: Figure 1.4, Definition 1.5