

Intro to Discrete Structures



Today's lecture
Presented by:
Karl Palmskog

Tron—Animation by Craig Reynolds..
Written in an actor language

Discrete Structures (CS 173)

Gul Agha

Slides derived from version by
Derek Hoiem, University of Illinois

Today's class

- A little about research in Professor Agha's group
- Introduction to discrete structures
- Course logistics

Intro to Discrete Structures

Discrete Structures \neq Discreet Structures



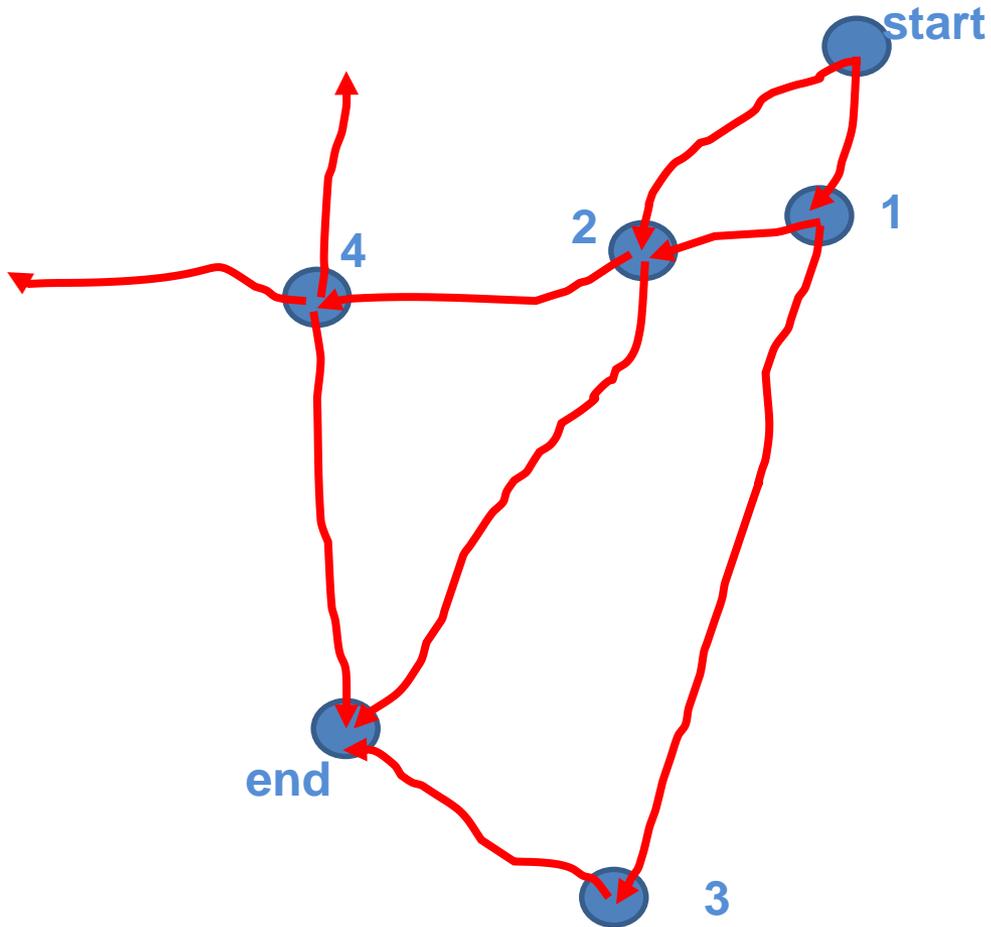
Discrete Structures

- We want to solve problems computationally
- This requires
 - modeling the world
 - devising an algorithm
 - determining the efficiency and correctness of that algorithm
- Discrete structures: how to model the world and think computationally and rigorously

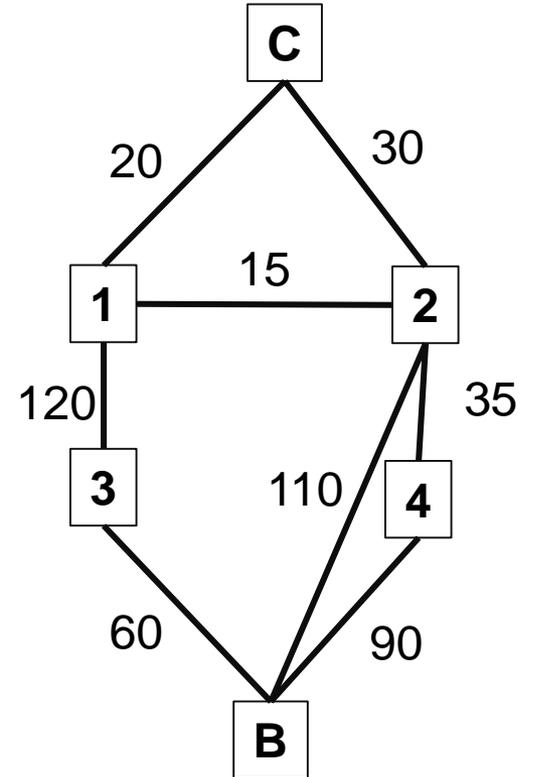
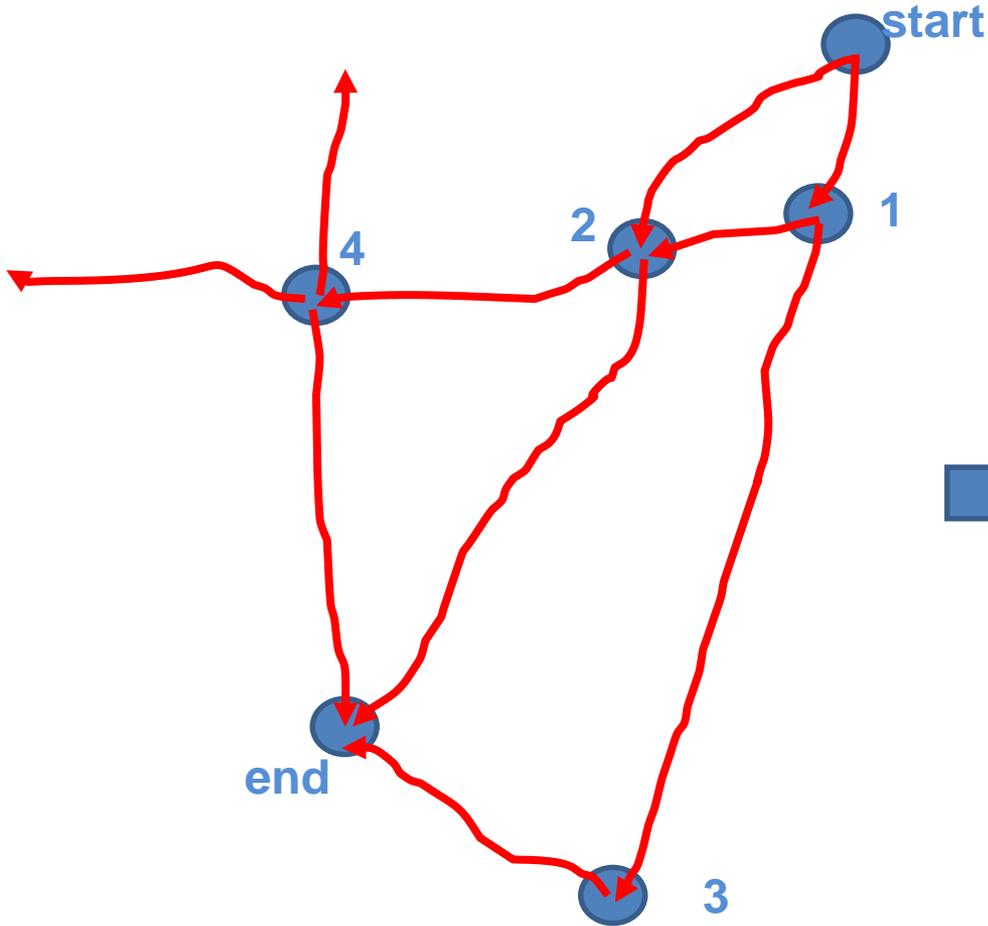
Fastest path from Chicago to Bloomington?



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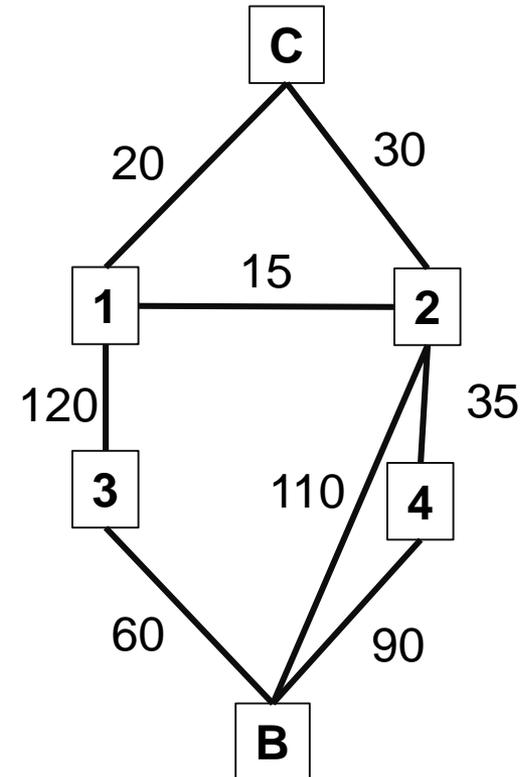
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Fastest path from Chicago to Bloomington?

Problem: find shortest path from C to B

- Many solutions: try random paths, enumerate all paths, depth first search



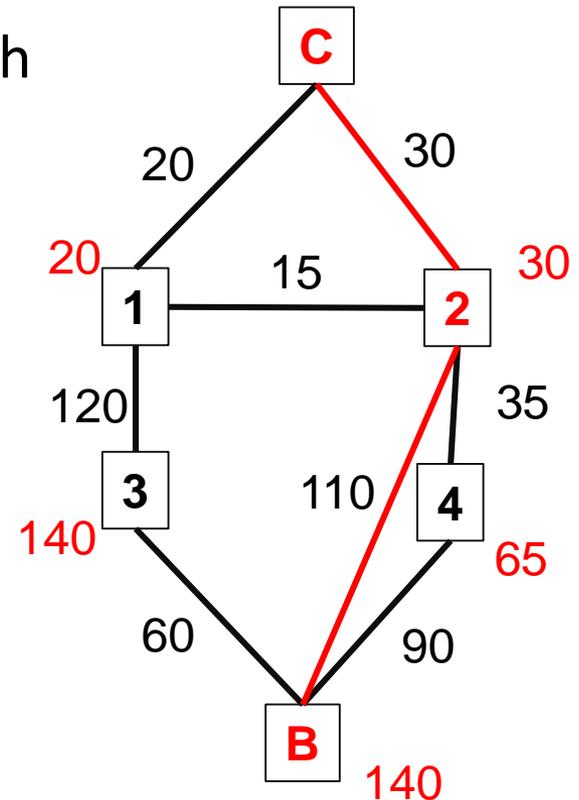
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Dijkstra's algorithm

- Explore neighboring nodes and keep track of shortest path to each



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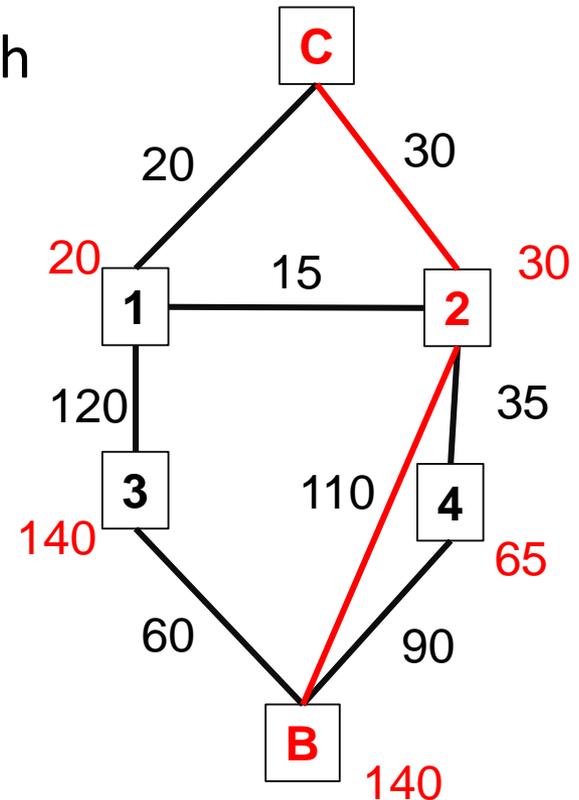
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How good is this algorithm?

- Does it find the best solution?
- How long does it take to compute?



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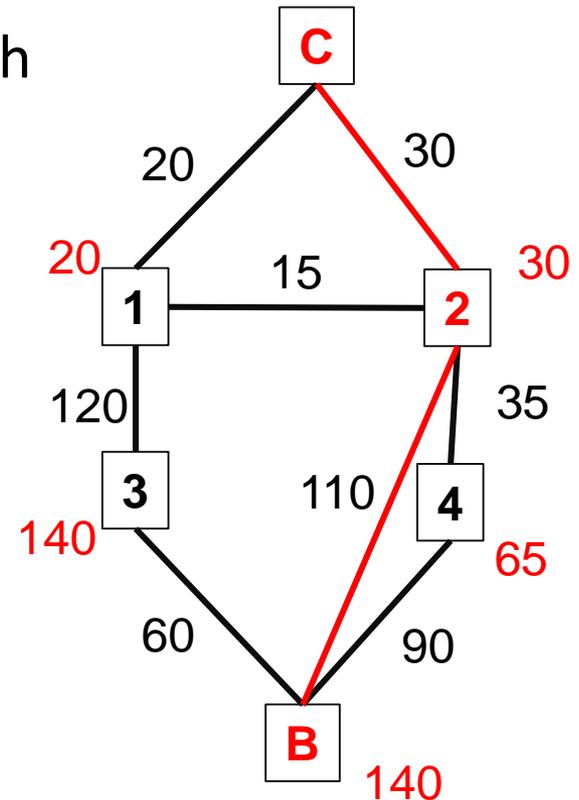
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Dijkstra's algorithm

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How good is this algorithm?

- Does it find the best solution?
- ~~How long does it take to compute?~~
- How does the computation grow as the number of vertices or edges increases?



Another example: recommender systems

- Shopper buys a “badonkadonk tank”

JL421 Badonkadonk Land Cruiser/Tank

by NAO

★★★★☆ (263 customer reviews) | Like (209)



Currently unavailable.

We don't know when or if this item will be back in stock.

Sell on
amazon

Sell this Product on Amazon

Just like you, there are thousands of other customers looking for the same product everyday. [Click here](#) to start selling on Amazon.

- What will she buy next?

Customers Who Viewed This Item Also Viewed

Page 1 of 7



5.17 CT Fancy Diamond and Platinum Ring (FY 4.01ct, RD 0.62ct, FY 0.54ct)
★★★★☆ (1)
\$125,000.00



SHOP FOX W1756 25 HP 43-Inch Three Phase Wide-belt Sander
\$16,899.00



Darth Vader Supreme Cost Adult SKU-PAS772688
\$1,129.19



Sharp, Provolone Piccante Cheese (Whole Wheel)
Approximately 60 Lbs
\$849.53

Add to Cart

In stock. Ships from and sold by The Gourmet



LOTR Narsil Sword
★★★★☆ (1)
\$175.99



Zanies 7-Inch Plush Squeaktoy Dog Toy, Pig
\$7.57



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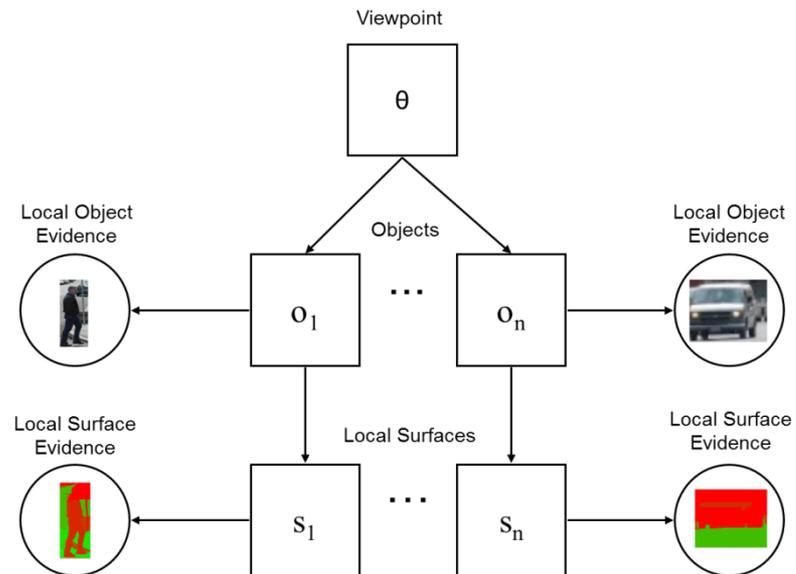
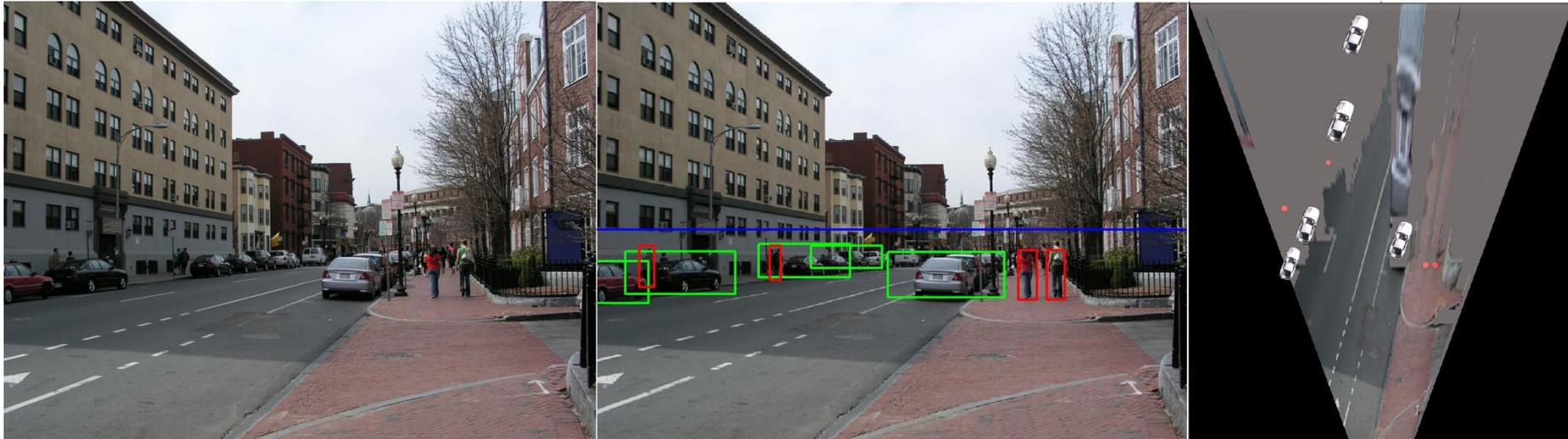
- What will she buy next?

Customers Who Viewed This Item Also Viewed



- Solutions
 - Frequent itemset mining: find sets of items that are often purchased or viewed within the same browser episode
 - Associative graph: learn probability of transition between product pages and compute overall strength of connection

Example from my research: Object Recognition



Graphical Model for Reasoning

What you'll learn in this course

- How to model the world
 - Logic, sets, trees, graphs, functions, state diagrams, etc.
- Strategies to prove and disprove statements
 - Direct, proof by example, use of cases, contrapositive, contradiction, contrapositive, induction
- How to model the computational behavior of algorithms
- How to think computationally

Examples of claims to prove or disprove

- There is no prime number that is larger than all the others.
- There is some compression scheme that can make every file smaller.
- Any dollar amount greater than \$3 can be made with \$2 and \$5 bills.
- Merge sort is $O(n \log n)$
- Some infinite numbers are larger than others.

Course Logistics: Weekly Schedule

Time	Monday	Tuesday	Wednesday	Thursday	Friday
Class		Lecture 11am-12:15pm		Lecture 11am-12:15pm Examlet every other week	
Office Hours		Agha 12:15-1:30			
Discussion Sections				Discussion Sect. 2pm-6pm	Discussion Sect. 10am-12pm, 4pm-5pm
Homework		Reading Quiz due 11:45pm (material from that day)	HW due 11:45pm	Reading Quiz due 11:45pm (material from that day, if no exam)	

- Tues: come to class, read textbook, complete reading quiz
- Wed: submit HW if not done already
- Thurs: come to class: Exam every other week (starting third week of class), read textbook, complete reading quiz on Lecture (no exam) Thursdays
- Thurs/Fri: attend your discussion section
- Weekend: complete as much of HW as possible
- Throughout week: attend office hours, as needed

Course Logistics: Grading

- Homework (25%)
 - Reading quiz: 5% (lowest 2 grades dropped)
 - Auto-graded: can see score, fix, and resubmit
 - Long-form HW: 15% (lowest dropped)
 - Discussion problems in recitation section: 5% (lowest dropped)
- Exams (75%)
 - Examlets 60%
 - Final Exam: 15%
- Late policy
 - Generally, late assignments not accepted
 - See website for details
- Cheating
 - <http://courses.engr.illinois.edu/cs173/sp2014/B-lecture/Common/cheating.html>

Course Logistics: Grading

- Thresholds for guaranteed grades
 - A 94%
 - A- 90%
 - B- 80%
 - C- 70%
 - D- 60%
- We reserve right to *curve up*
- In previous terms, this course has given about 20% A's, 30% B's, 30% C's, 15% D's, and 5% F's

Materials

- Required
 - Margaret Fleck’s “Building Blocks for Theoretical Computer Science”
 - Purchase hardcopy from bookstore (\$18)
 - Can also download online: <http://www.cs.uiuc.edu/~mfleck/building-blocks/>
 - Discussion packet (\$5)
 - Duplicate-page notebook (\$15)
- Optional Books on Reserve in Grainger Library
 - Rosen “Discrete Mathematics and its Applications”, 5th to 7th edition
 - Liebeck, Martin; A Concise Introduction to Pure Mathematics, 3rd ed.
 - Biggs, Norman; Discrete Mathematics, 2nd Edition
 - More detail, practice problems

Getting help

- Discussion sections and office hours

<http://courses.engr.illinois.edu/cs173/sp2016/B-lecture/Common/staff.html>

- Starts next week!

- Newsgroup: piazza.com

piazza.com/illinois/fall2016/cs173

- Major problems

<http://courses.engr.illinois.edu/cs173/sp2016/B-lecture/Common/help.html>

Tips

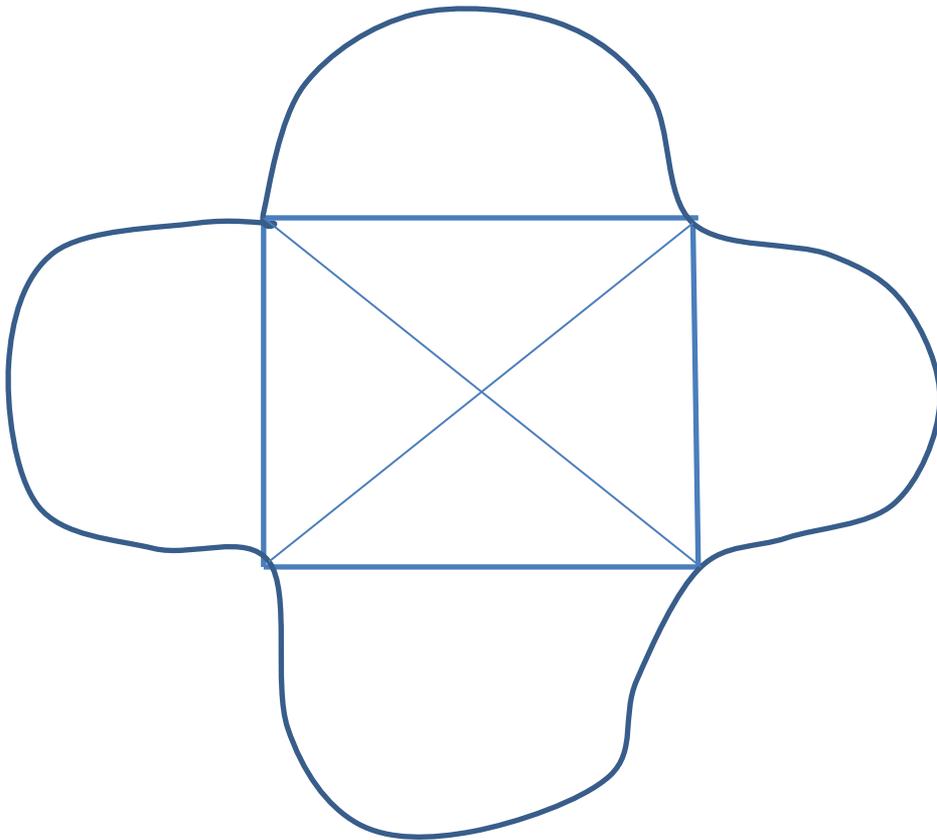
- This class is difficult for most students
- New ways of thinking require lots of practice
- Basic approach to taking this class
 - Come to lectures, take notes
 - If you have trouble following lecture, read the relevant sections of the book first
 - Try the homework
 - Read the online textbook
 - Complete the homework (use TAs, Piazza, Rosen book, online resources as needed)
- Preparing for exams
 - Find extra problems from past homeworks and exams (see past courses linked via website)
 - Do a few extra problems every week in a topic that is difficult for you

To do now

1. Read syllabus and course information online (click B lecture)
<http://courses.engr.illinois.edu/cs173>
2. Fill out “prereq and info” form if not done already:
<https://illinois.edu/fb/sec/9331220>
3. Enroll in Piazza to get announcements
Signup Link: piazza.com/illinois/fall2016/cs173
 - If you are not enrolled, you should have received email
 - You are *not required to use Illinois.edu*, if you want to use a different email address let us know
4. Make sure you can access Moodle
 - First “reading quiz” on Thursday (due at midnight)
5. If you’re not yet registered, come up front after lecture and put your name on a list. Also, use online form available from main course page
6. Note: no discussion section this week!

A puzzle

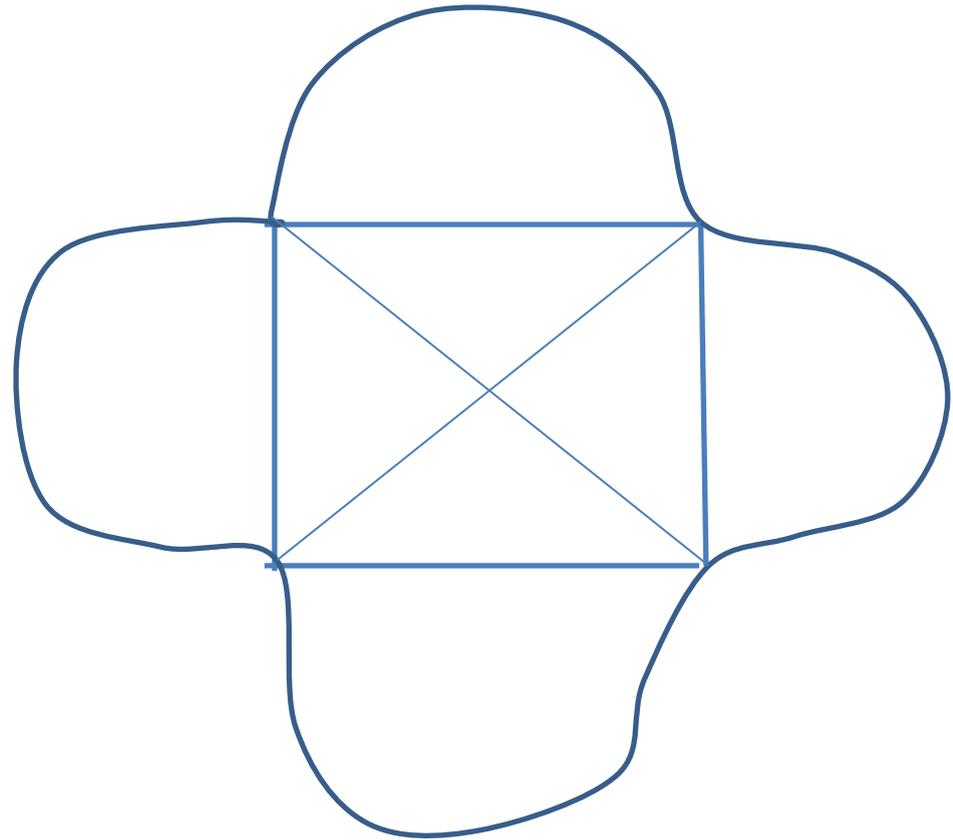
- Can you draw this on paper, without retracing any line/curve and without removing your pencil from the paper?



Proofs

How do you convince a fellow human being (or your roommate) that something is really really true?

Eg. How do you show him/her that drawing this is impossible?



Propositions

- Statements that have a true/false value.
- Examples of propositions
 - I am male.
 - 34 is less than 20.
 - If the sky is blue, then the clouds are yellow.
- Examples of non-propositions
 - $x > 5$
 - Do your homework.
 - Is the sky blue?

Logical Operators and Truth Tables

- T, F, AND (\wedge), OR (\vee), xor, not (\neg)
 - On overhead
- Important:
 - “x AND y” is true only if both x and y are true
 - “x OR y” is true if x is true, if y is true, or if both x and y are true
- Examples: $p \wedge q, p \vee q, p \vee T, p \wedge F, p \text{ xor } q, \text{not } p$
 - True or false? I am 33 or 97. I am 33 and 97. I voted for Obama or Romney.

overhead (2.1,2.2)

Implication

- Implies
 - x implies y , $x \rightarrow y$
 - If x , then y
 - When x is true, then y is always true.
- Examples
 - If it is a dog, then it can walk.
 - Every time I look at you, I go blind.
- Important: if the hypothesis is false, then the implication is always true
 - “If false, then false” is a true statement
- Bi-implies: $x \leftrightarrow y$
 - Both statements must be true (or false) at the same time
- Chaining implications: if $x \rightarrow y$ and $y \rightarrow z$, then $x \rightarrow z$

Translating English into Propositional Logic

Lewis Carroll Logic Puzzle

1. All babies are illogical.
2. Nobody is despised who can manage a crocodile.
3. Illogical persons are despised.

Manipulation and equivalence

- Logical Equivalence: two propositions are equivalent if they have the same T/F values for all cases
- DeMorgan's Laws
- Distributive and commutative laws
- $a \rightarrow b \equiv \neg a \vee b$