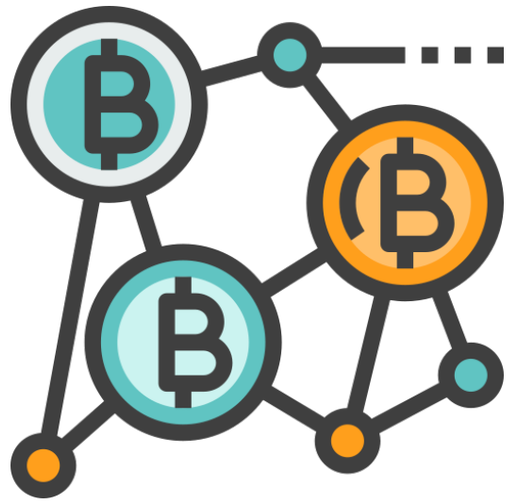
CS 357: Algorithmic Game Theory
Lecture 1: Course Overview

Shikha Singh

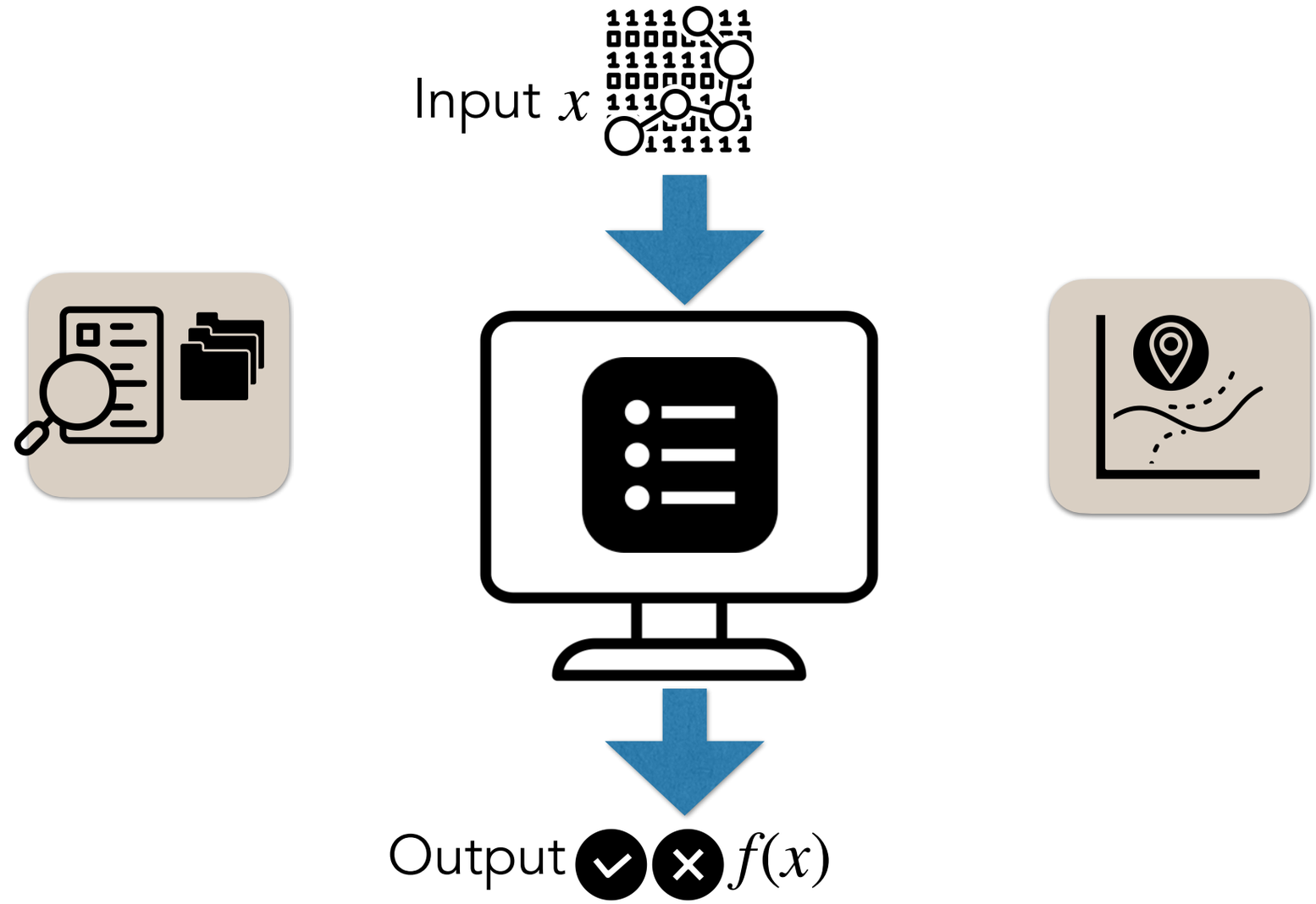
Introductions

What is Algorithmic Game Theory?



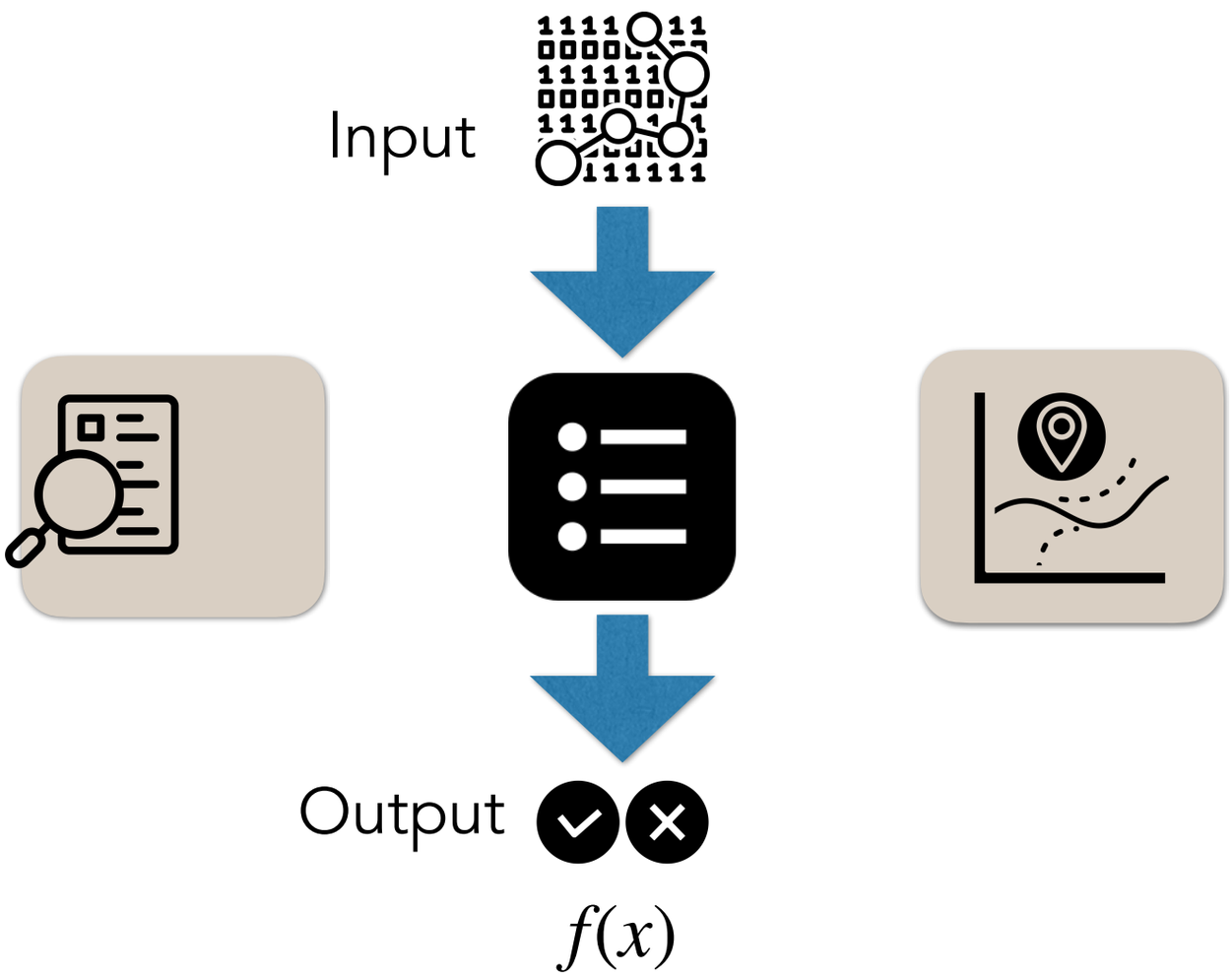
What its not about...

Algorithms



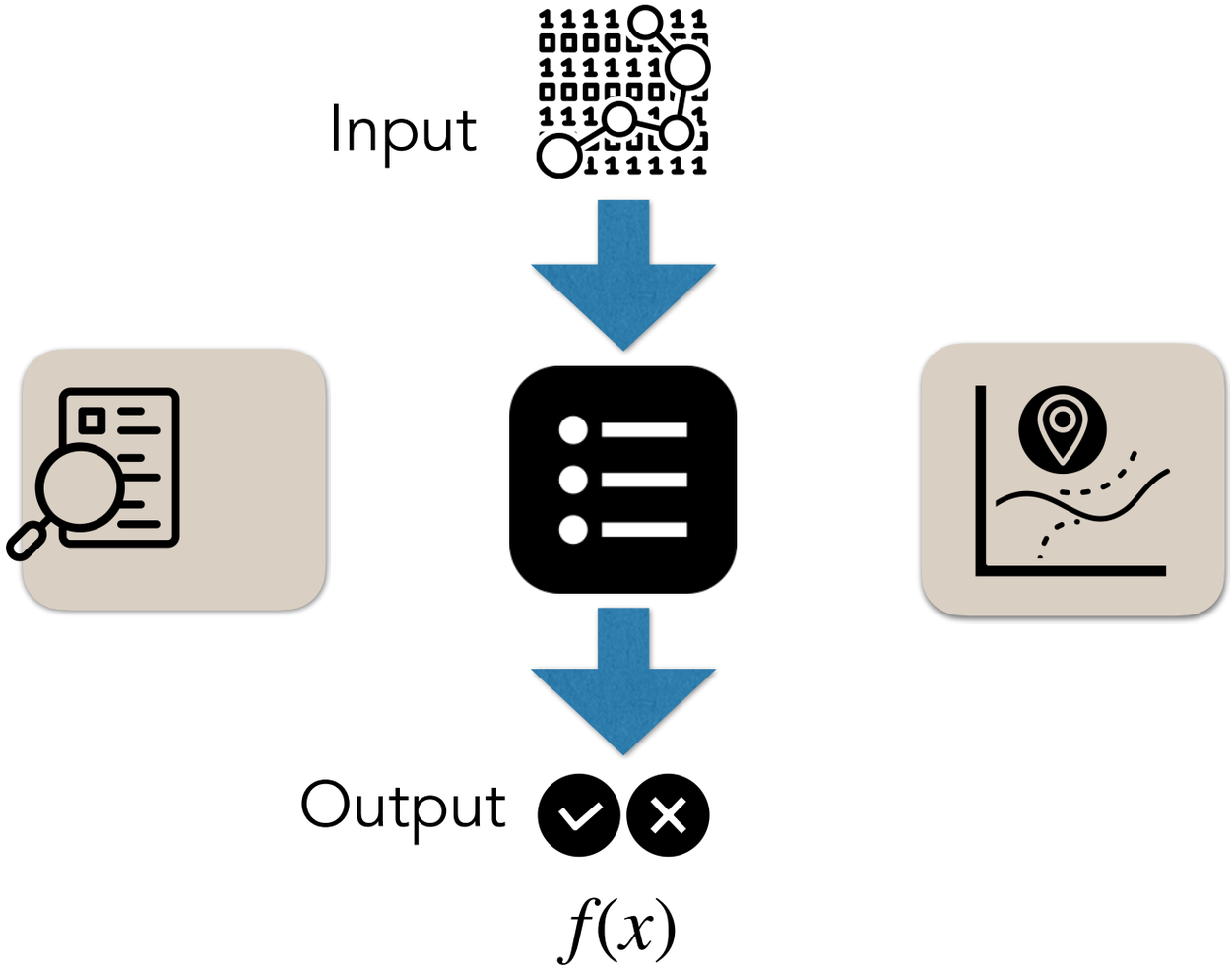
"Computer" Algorithms

- **Question:** Examples of algorithms from 256?
- What were we trying to optimize?
- What were we trying to analyze?
- Types of input / output

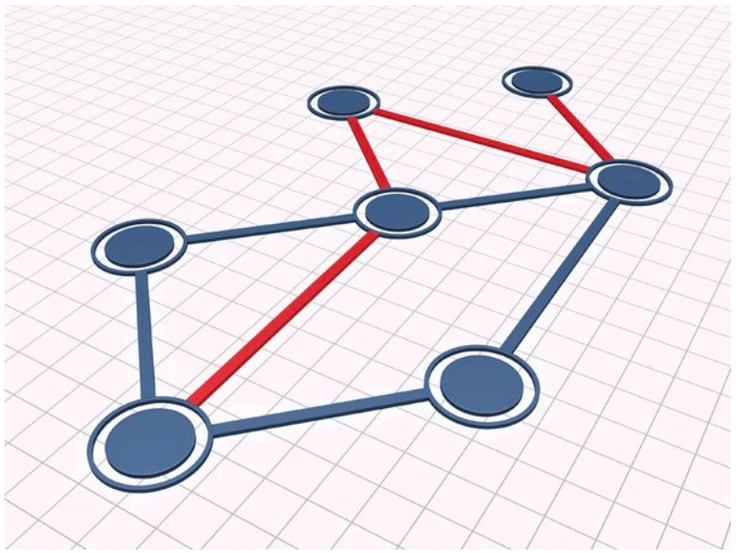


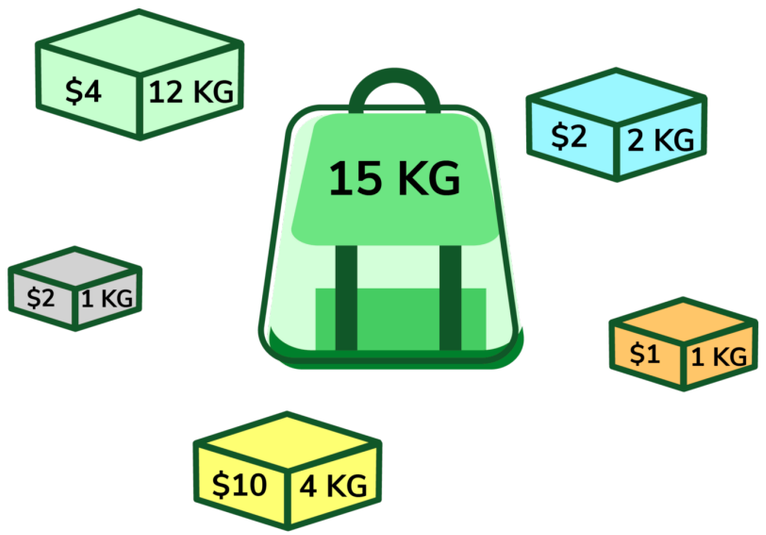
"Real World" Algorithms

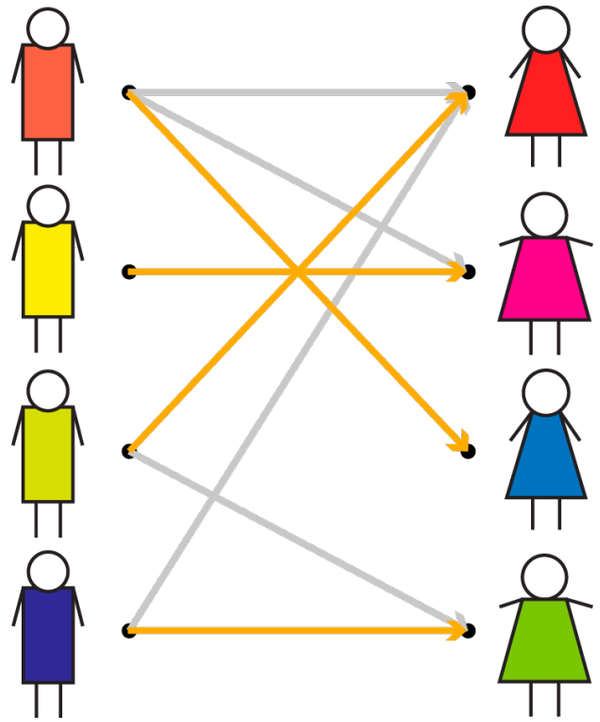
- Procedures/ mechanism that get used to make decisions
- Input: people's private information (preferences or beliefs)
- Output: an allocation or decision or outcome
- Examples?



"Real World" Algorithms







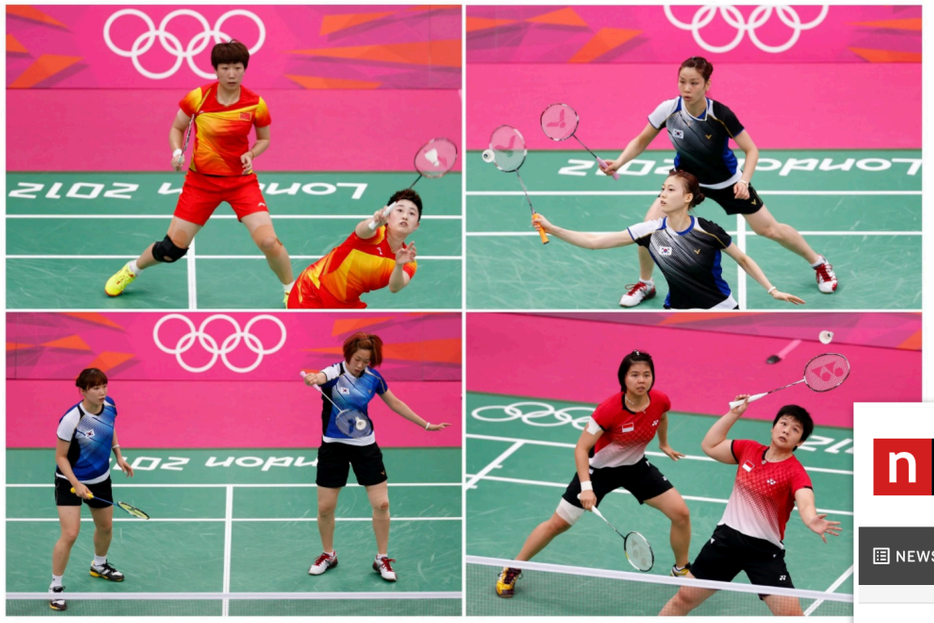
Central Theme

How does strategic behavior affect the outcome of an algorithm?

Goal of participants may not always align with that of the algorithm designer

2012 Olympics Badminton

Olympic Ideal Takes Beating in Badminton



Clockwise from top left, the women's badminton doubles pairs: China's Wang Xiaoli, left, and Yu Yan
South Korea's Jung Kyung-eun, top, and Kim Ha-na; Indonesia's Greysia Polii and Meiliana Jauhari
South Korea's Ha Jung-eun and Kim Min-jung during matches in London. The players were charged
misconduct by the World Badminton Federation. Bazuki Muhammad/Reuters

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SPORTS

Throwing Games: Is It Strategy Or Cheating?

August 1, 2012 · 1:00 PM ET
Heard on Talk of the Nation

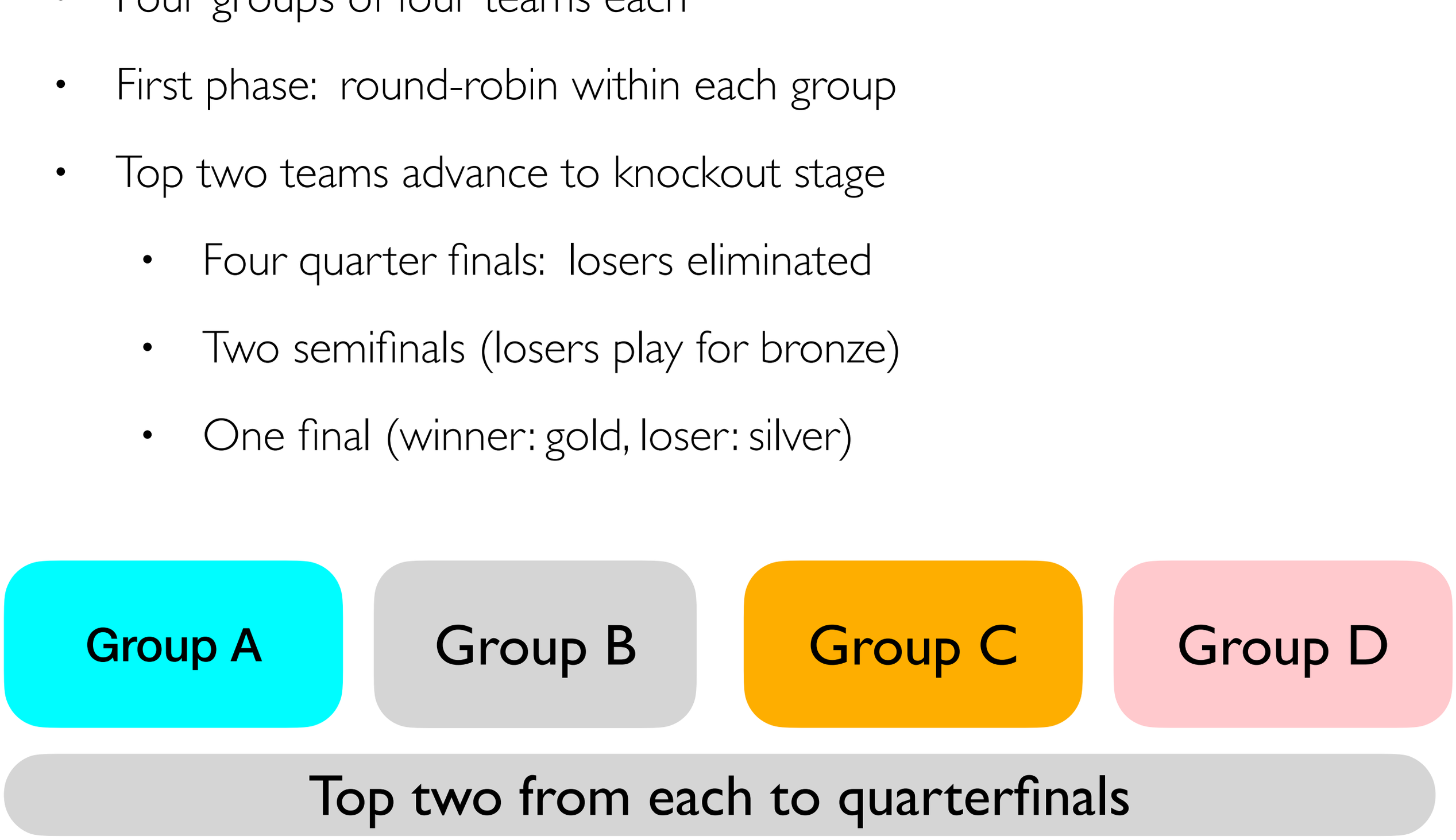
16-Minute Listen + PLAYLIST

Four teams were ejected from Olympic badminton competition after allegedly throwing games in an effort to engineer easier paths to the medal stand. NPR's Howard Berkes and Tom Goldman discuss how it has thrown the tournament into chaos, and raised questions about sportsmanship and strategy.

Transcript

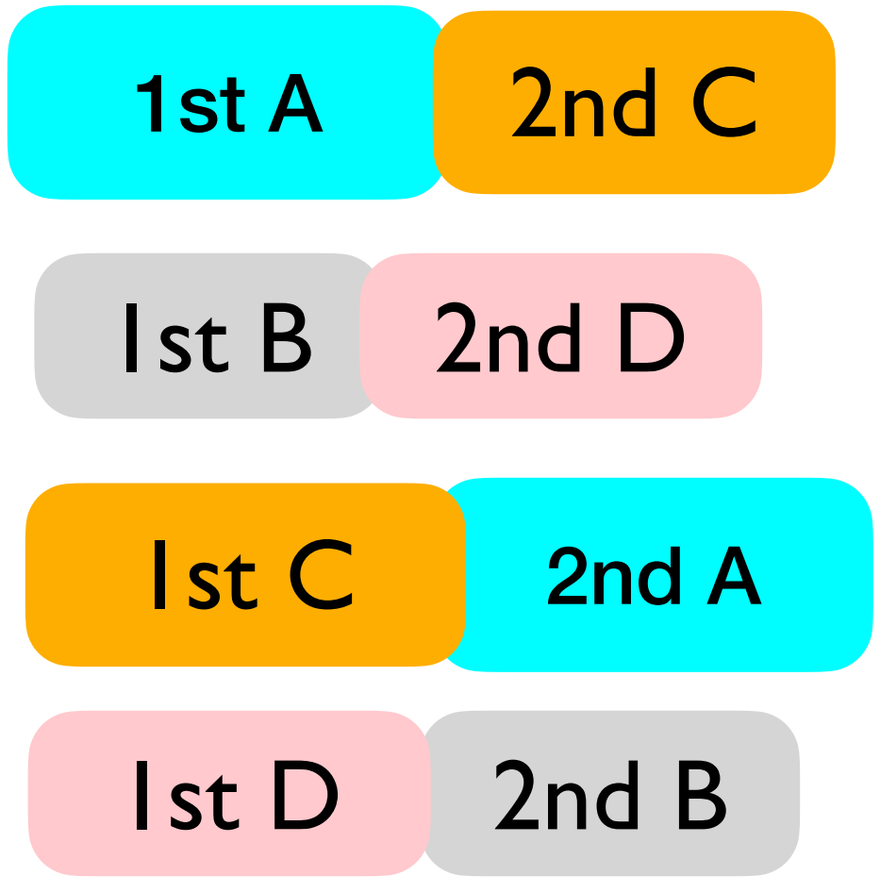
Rules of the Game

- Four groups of four teams each
- First phase: round-robin within each group
- Top two teams advance to knockout stage
    - Four quarter finals: losers eliminated
    - Two semifinals (losers play for bronze)
    - One final (winner: gold, loser: silver)



Rules of the Game

- How are teams paired in knockouts?
  - Best from A plays second-best team from C in the 1st quarterfinal
  - Best from C plays the second-best from group A in the 3rd quarterfinal.
  - Top two teams from B and D are paired up analogously in the 2nd and 4th quarterfinals.



What Do Players Want?

Gold > Silver > Bronze > Nothing

What Do Organizers Want?

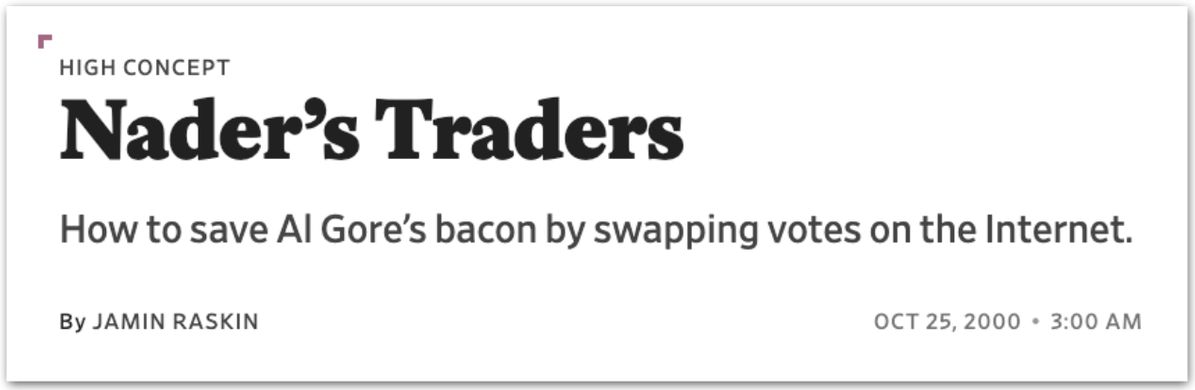
What Went Wrong

- Chinese team Tian and Zhao (TZ): favored team to win
- Last day of round-robin: shocking upset
  - Danish team Pedersen and Juhl (PJ) beat the TZ
- First controversial match between Chinese team Xiaoli & Yang (XY) and S Korean team Kyung-eun & Ha-na (KH)
  - Both teams were guaranteed to move to knockouts
  - Winner: faces TZ in semifinals (can win bronze)
  - Loser: faces TZ in finals (silver guaranteed)
  - So... both teams tried to deliberately lose the game
- Video: https://youtu.be/7mq1ioqiWEo?t=791

"*The next time we bemoan people exploiting loopholes to subvert the intent of the rule makers, instead of asking 'What's wrong with these people?" let's instead ask, `What's wrong with the rules?' and then adopt a scientifically principled approach to fixing them*" —
Hartline and Kleinberg

Incentives Matter: Voting

- System designer's goal: to elicit truthful preferences over candidates
- Why voters may not vote truthfully?
- Bush vs Gore 2000 US Presidential Election
  - Nader traders: https://slate.com/news-and-politics/2000/10/nader-s-traders.html
- Tactical voting can be reduced by instant-runoff voting, a system where voters cast ballots ranking the candidates

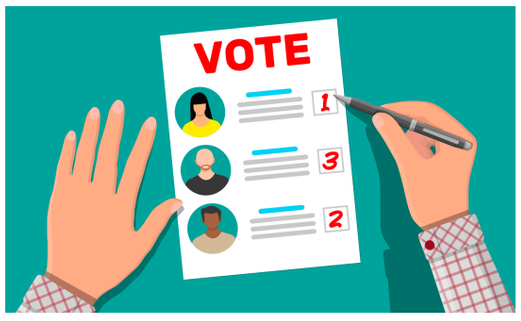

HIGH CONCEPT

Nader's Traders

How to save Al Gore's bacon by swapping votes on the Internet.

By JAMIN RASKIN

OCT 25, 2000 • 3:00 AM

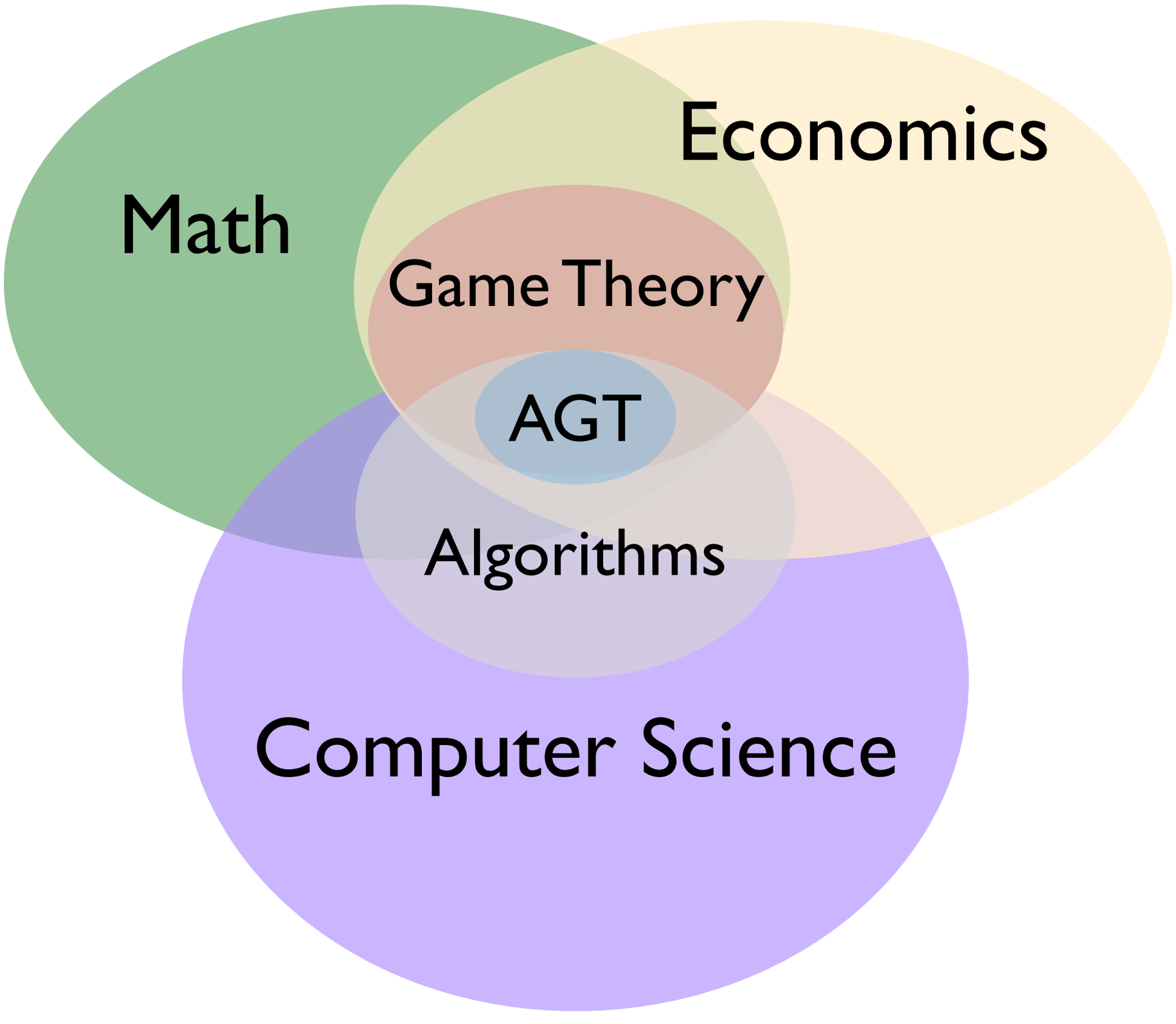


Classroom exercise:

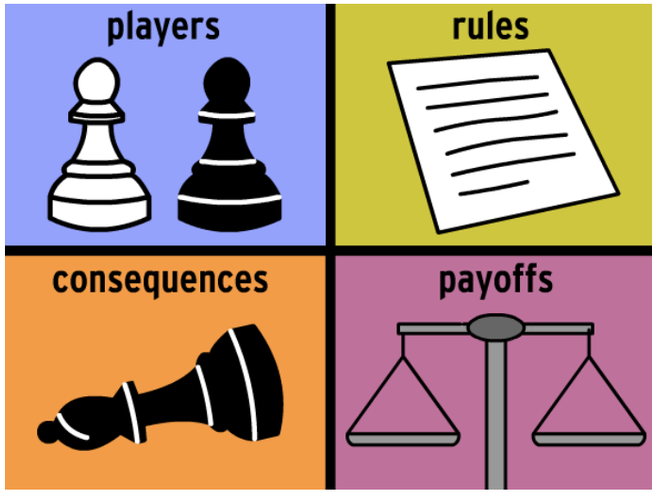
Can you come up with examples of procedures/algorithms in your life where the rules do not necessarily lead to desirable behavior or have unintended consequences?

Or on the flip side: examples of well-incentivized algorithms?

Interdisciplinary Area



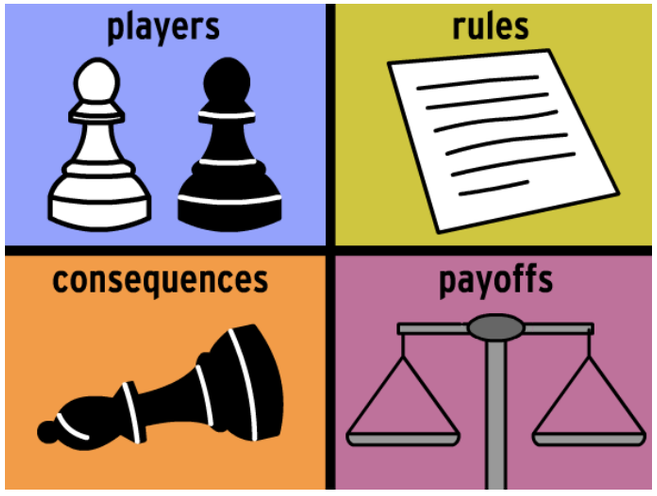
Algorithmic Game Theory



- Study of strategic interactions between strategic/rational players
- Players play to maximize their utility in the game
- Pre-existing rules
- Goal is to analyze strategic behavior or figure out winning strategy

- Specify rules that given an input, produce a desired output/outcome
- Design goals:
  - Optimize an objective function
  - Efficiency and simplicity
  - Quality of outcome

Two Big Themes



- How to **design** incentives in algorithms such that the system designer's goal matches that of the participants
- How to analyze selfish behavior?
  - How bad is it anyway?
  - CS approach different from GT

When and How it Came About

- Relatively new field (~15 years or so)
- Gained momentum due to the Internet & e-commerce
- Also called **Economics and Computation**
- Economic to CS:
    - Incentives in resource allocation, online advertising, file sharing, etc
- CS to Econ:
    - Efficiency
    - Approximations
    - Complexity

Background

- Algorithms (CSCI 256)
- Basic probability (MATH 200)
- Some multi-variable calculus
- Overall: comfort with abstract models, logic, and proofs

Course Breakdown

- Some vanilla game theory (for background)
- Markets (Econ), Resource-allocation algorithms (CS)
  - Markets with money (auctions)
  - Markets without money (matching problems)
  - Social choice (how to make decisions as a group)
- Incentives in CS and decentralized systems:
  - Network routing and price of anarchy
  - P2P systems
- Misc topics: extensive-form games and applications

Applications

- Study real-world applications
  - Internet ad-search: how it works and why
  - National resident matching program
  - Top trading cycles for kidney exchange and school assignment
  - Voting rules and fair division
  - Network routing (BGP)
  - P2P System (File sharing and torrents)

Course Logistics

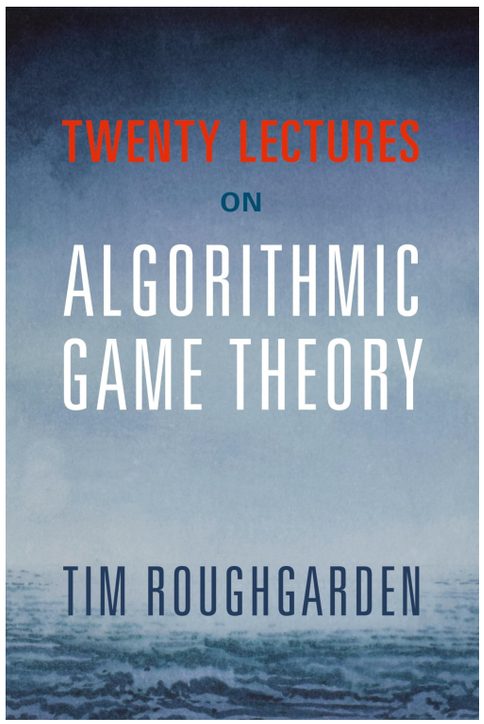
Textbooks

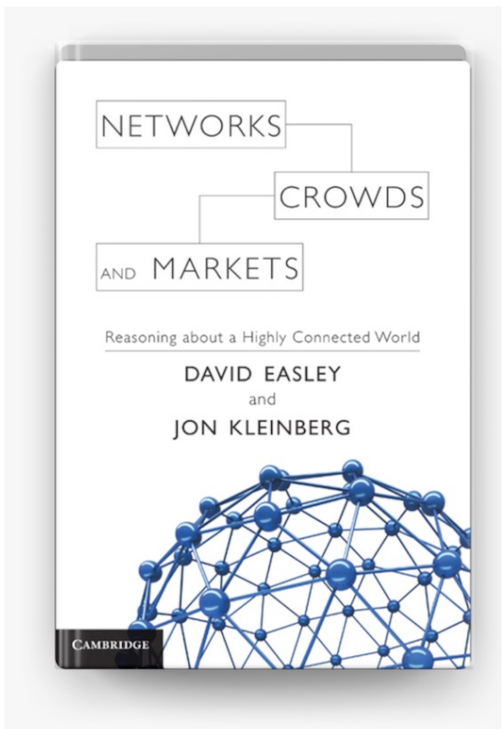
- No canonical textbook
- Readings will be assigned from many different ones or from papers

Economics and Computation

David C. Parkes
School of Engineering & Applied Sciences
Harvard University
parkes@eecs.harvard.edu

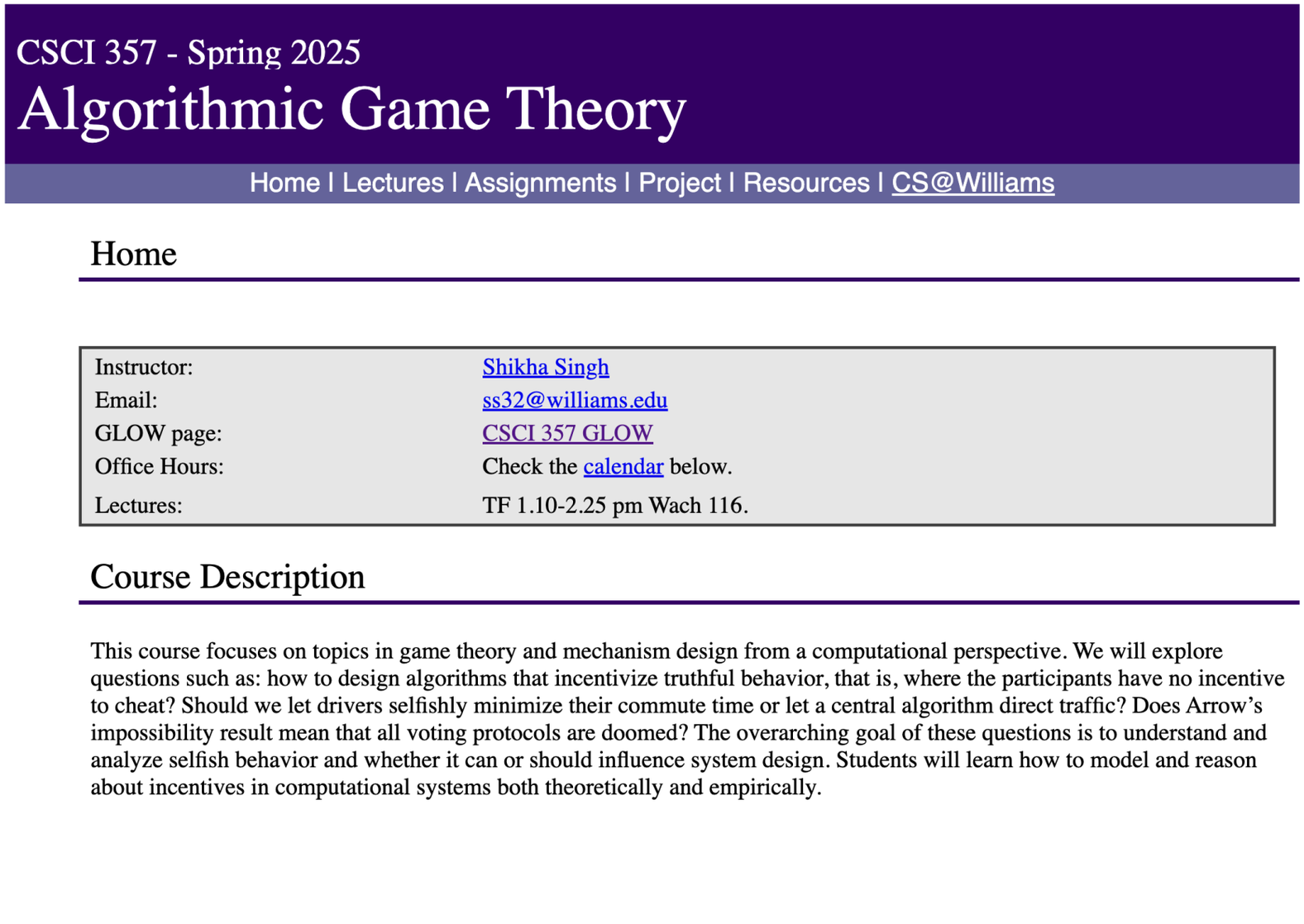
Sven Seuken
Department of Informatics
University of Zurich
seuken@ifi.uzh.ch





Course Webpage

- Link: https://williams-cs.github.io/cs357-s25/
- Lecture materials, readings and assignments will be posted here
- Will occasionally use GLOW for internal documents


CSCI 357 - Spring 2025

Algorithmic Game Theory

Home | Lectures | Assignments | Project | Resources | CS@Williams

Home

Instructor:	Shikha Singh
Email:	ss32@williams.edu
GLOW page:	CSCI 357 GLOW
Office Hours:	Check the calendar below.
Lectures:	TF 1.10-2.25 pm Wach 116.

Course Description

This course focuses on topics in game theory and mechanism design from a computational perspective. We will explore questions such as: how to design algorithms that incentivize truthful behavior, that is, where the participants have no incentive to cheat? Should we let drivers selfishly minimize their commute time or let a central algorithm direct traffic? Does Arrow's impossibility result mean that all voting protocols are doomed? The overarching goal of these questions is to understand and analyze selfish behavior and whether it can or should influence system design. Students will learn how to model and reason about incentives in computational systems both theoretically and empirically.

Syllabus and Grade Breakdown

- Posted on course webpage
  - https://williams-cs.github.io/cs357-s25/handouts/syllabus.pdf
- Grading breakdown (many components):
  - Homework (10%)
  - Paper evaluations (10%)
  - Attendance and Class Participation (5%)
  - Exams (15 + 15%)
  - Assignments (20%)
  - Final Project (25%)

Syllabus and Grade Breakdown

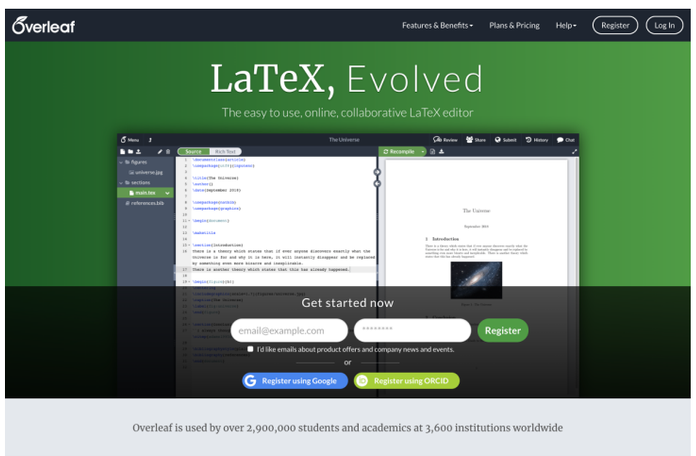
- Posted on course webpage
  - https://williams-cs.github.io/cs357-s25/handouts/syllabus.pdf
- Grading breakdown (many components):
  - Homework (10%): *weekly, pen-and-paper, solo*
  - Paper evaluations (10%): *~ four, present in class in groups*
  - Attendance and Class Participation (5%): *most imp!*
  - Exams (15 + 15%): *two, in class, test understanding of concepts*
  - Assignments (20%): *LaTeX, longer, in pairs, every 1.5-2 weeks*
  - Final Project (25%): *last 3 weeks*

Homework

- Low-stakes short-answer questions on paper
- Practice with definitions and readings
- Must hand it in class (form of attendance)
- **No late homework** will be accepted
  - If you cannot make it to class, place it in my mailbox ahead of time
- Lowest two will be dropped
- HW 1 will be released next lecture and due following Tuesday

Assignments

- Longer proof or coding based, typeset in LaTex
- Need to submit via gradescope, occasionally over Github
- Must be done in pairs
  - can help coordinate finding partner
- Oral component for feedback:
  - "Demos" : explain your logic in office hours
- **Assignment 1** released next Tuesday and due following Thursday



Attendance and Class Participation

- Important to come to class
    - Lots of classroom discussion and group activities
- Attendance will be taken
    - Tuesdays via HW
    - Fridays via classroom activity
- Everyone can miss two-lectures without an excuse
- Otherwise, if you need to miss, reach out ahead of time

Classroom Culture

- A good learning experience for all requires you to engage
    - Be a good teammate, come prepared and contribute
- Help and support each other and to build a positive classroom community
- Class participation does not mean dominating classroom discussions or interrupting your peers
- There are no wrong answers in my class!
- Be respectful and kind to each other

Bottom line. *Help create a vibrant, positive, and inclusive classroom environment!*

Honor Code

- Read: academic honesty section of the syllabus
- Gist:
    - No collaboration on HW
    - Only collaborate with your partner on assignment
    - Can help others find resources/ answer clarifying questions
    - No internet/ ChatGPT **unless stated explicitly** that is OK
- You must understand the work you submit

Bottom line. *Any work that is not your own is a violation of the Honor Code.*

Course Support

- No TAs
- Instructor Office Hours:
    - Will set so that most of you can make it (but not always possible)
    - Please give availability in google form