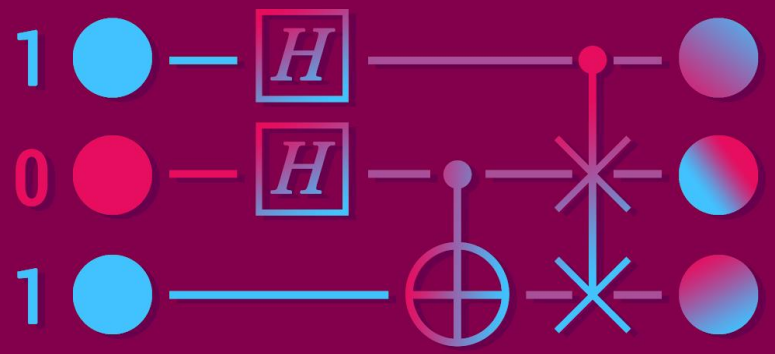
Big-O Theory Club

The fun is theoretical, but the science is real!

...wait

THEORY CLUB

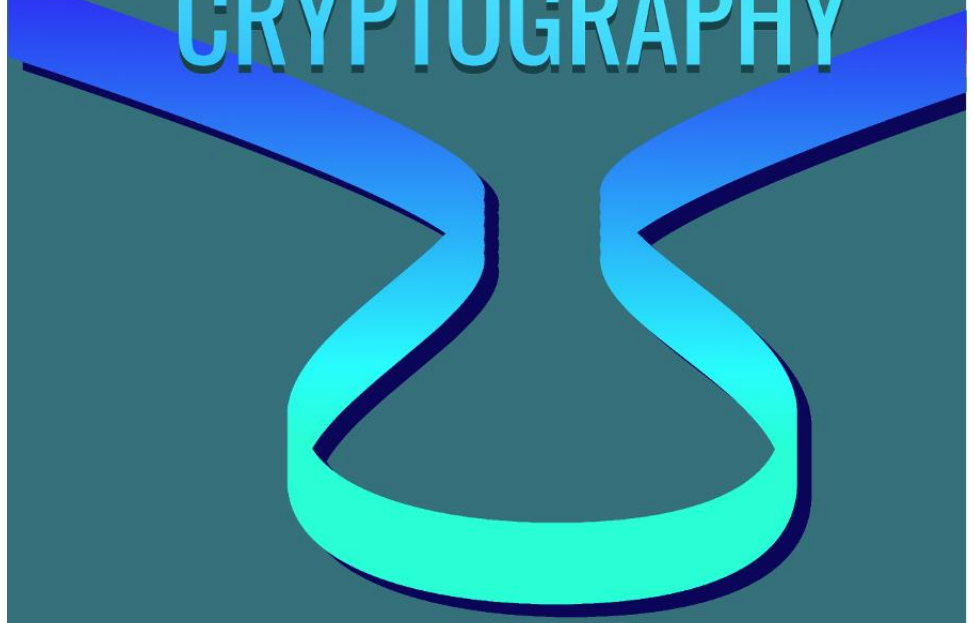
QUANTUM COMPUTING ALGORITHMS



ES&T L1175: 02/27 @6PM
with
DEVON INGRAM

THEORY CLUB

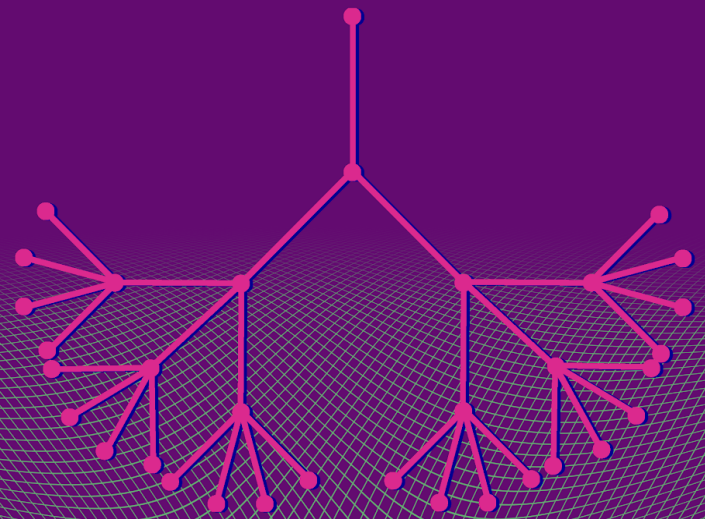
ELLIPTIC CURVE CRYPTOGRAPHY



ES&T L1175: 04/03 @6PM
with
PROFESSOR MATTHEW BAKER

THEORY CLUB

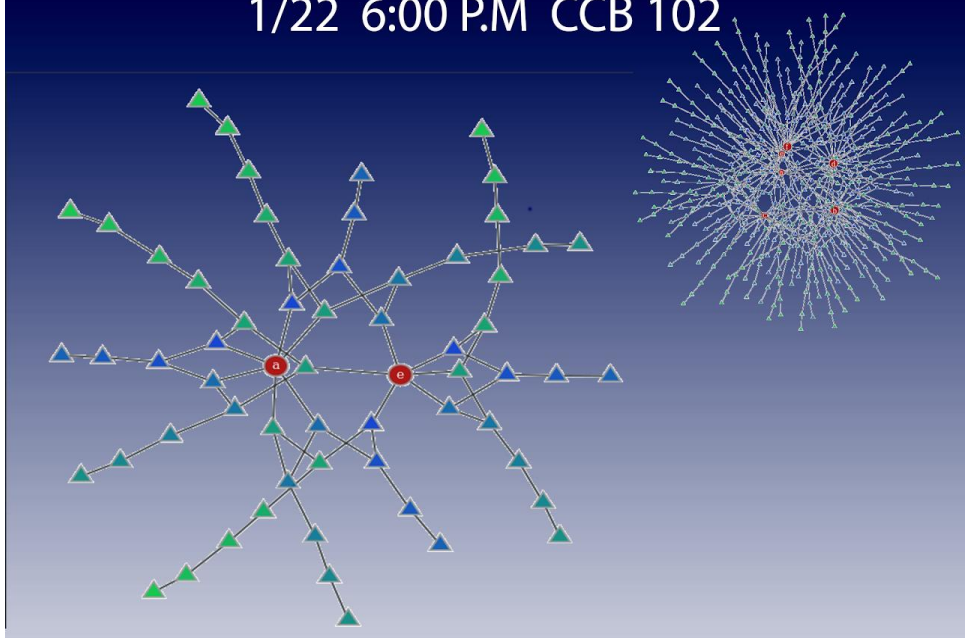
PROBLEM SESSION



CCB 102: 02/26 @6PM
with
SHERRY SARKAR

THEORY CLUB

1/22 6:00 P.M CCB 102

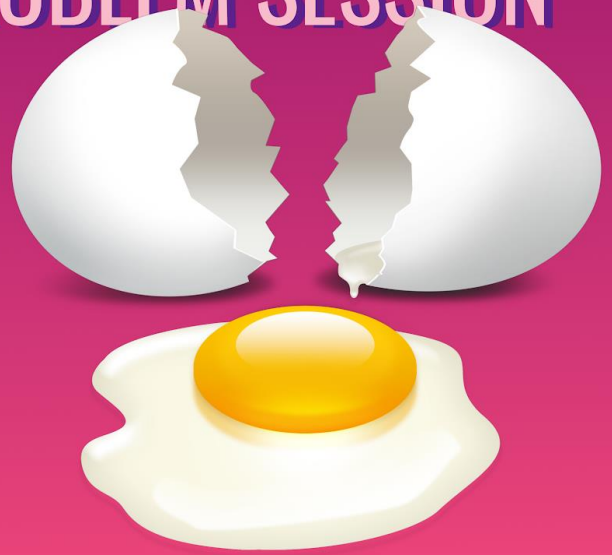


REDUCING THE GROUP ISOMORPHISM PROBLEM TO THE **GRAPH ISOMORPHISM PROBLEM**

BY DANIEL HATHCOCK

THEORY CLUB

SPRINGTIME PROBLEM SESSION



CCB 102: 03/26 @6PM
with
SHYAMAL PATEL

THEORY CLUB

SYNCHRONOUS CHAOS

AKA THEORY CLUB

ELECTIONS

CCB 102: 04/23 @6PM
with
DIPTODIP DEB

General Information

General Meetings

- Professor Talks
- Student Talks
- Problem Sessions every 5-ish weeks
- ARC speakers
- Proof based
- No coding

Goal of Meetings

- See theory CS outside the GT curriculum
- Show what our faculty are researching
- Everyone leaves understanding something

Prerequisites

- Meetings are proof based.
- You don’t need to be good at proofs or math to come to our meetings - you just have to be interested!

Officers

Arvind Ramaswami

President

Neil Thistlewaite

Vice President

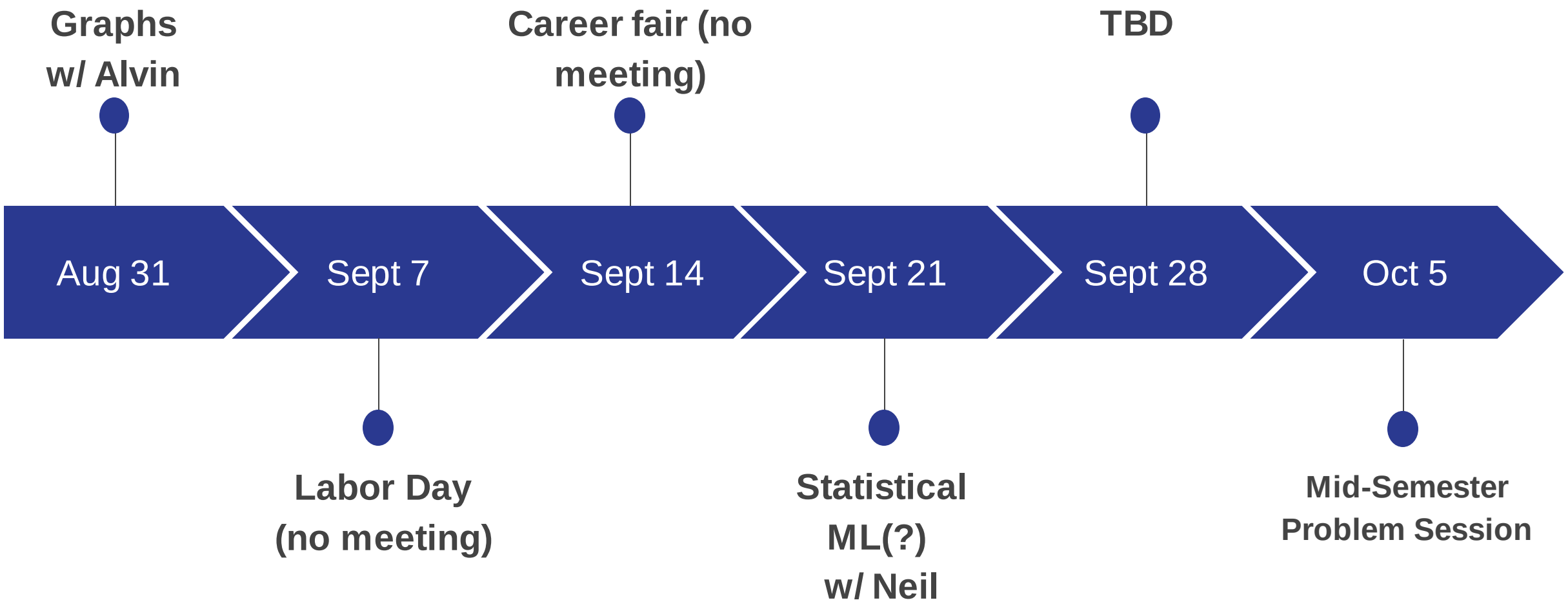
Alvin Chu

Talks Coordinator

Atul Merchia

Workshops Coordinator

Tentative Schedule for Upcoming Meetings

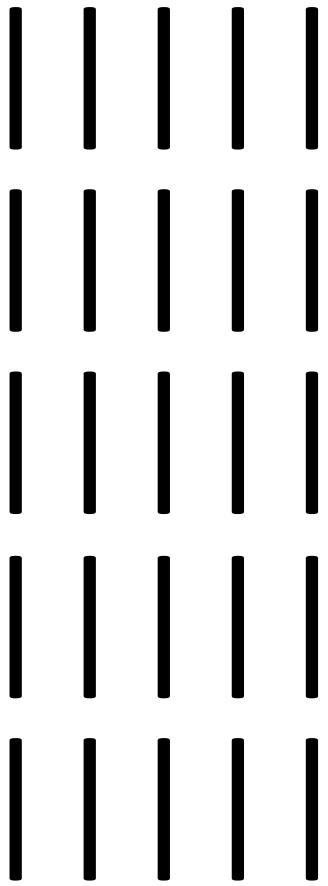


Variant of Nim

Rules:

- Start with n paper clips
- Player 1 can pick up to at most n – 1 paper clips
- The players alternate and can take up to at most 2 times the number taken in the previous turn
- Goal: Take the last paper clip

You try!



Solution

The losing positions are the **Fibonacci numbers**

F_n = 1, 1, 2, 3, 5, 8, 13, 21

20 -> 14 -> 13

- The winning strategy: found using the Zeckendorf decomposition* of n (using the greedy algorithm)
- Remove the smallest part of the decomposition

13 + 5 + 2 = 21

14 = 13 + 1 => remove 1

*Zeckendorf decomposition: representation of an integer as a sum of nonconsecutive Fibonacci numbers

Why is it the Fibonacci Numbers?

•**Lemma: 2 * F_i < F_{i + 2}**

- This implies that...
  - removing the smallest Zeckendorf part **will never allow the other player** to remove the next smallest Zeckendorf part
- For example,
  - 19 = 13 + 5 + 1
  - The first player removes 1 paper clip.
  - The next player is **forced to play the losing position of 5** paper clips!
  - The second player starts the game of 5 paper clips (and inevitably loses). That means he/she **has to start the next losing position of 13 paper clips!**
- And **Player 2 loses!!**

So does Player 1 always win?

19 = 13 + 5 + 1
Remove 1: 18 = 13 + 5
P2 Remove 2: 16 = 13 + 3
Remove 3: 13
P2

Another game

- Two playing a game on a circular table.

Each turn:

- Each player places a penny on the table such that none of it hangs off the table, and none overlaps with an existing penny.
- A player loses if unable to place a penny on the table.

Who has the winning strategy?

An Introduction to CS Theory

What Questions Does CS Theory Consider?

Algorithms

- How fast can you compute the volume of a shape?
- How can you quickly compute a close to optimal route to visit a set of cities?
- How can you quickly sample a random schedule?
- Given a black box function, how many values do you need to know to be reasonably convinced that it is linear (or close to linear)?

Limits of Computation

- How many comparisons do you need to sort a list?
- Suppose you and a friend are given numbers, how many bits do you need to exchange to know if they are the same?
- Does randomness allow us to compute functions faster?
- Suppose we know that a solving a problem takes a long time, what other problems does this imply are slow?

What tools are used?

- Discrete Math:
  - Combinatorics
  - Graph Theory
- Continuous Math
  - Geometry and Calculus
  - Linear Algebra
- Algorithmic Ideas:
  - Binary Search
  - Data Structures
  - Dynamic Programming

Open Problems

Open Problem 1

- **Sum of Square Roots**
- Given a list of integers x_1, x_2, …, x_n and k can you determine if $\sqrt{x}_1 + \sqrt{x}_2 \cdots \sqrt{x}_n \leq k?$
- Can this be done in polynomial time?

Open Problem 2

- **All Pairs Shortest Paths**
- Given a weighted graph G=(V, E,w) does there exist a truly subcubic algorithm to find the distance between every pair of vertices?

Open Problem 3

- **P = NP?**
- For any problem whose solution can be checked in polynomial time, can we compute its solution in polynomial time?
- NP = RP? (recent paper refuted within 3 hours: https://arxiv.org/abs/2008.00601)