Recap

Questions?

Algorithms

- Polynomial Time
  - Stable Marriage
  - Perfect Bipartite Matching
  - MaxFlow
  - Maximum Weighted Bipartite Matching
  - Approximation for Vertex Cover (x 2)
    - Maximal Matching
    - Linear Programming relaxation
  - Set Cover
    - Greedy
  - Linear Programs and Duality
  - Learning Disjunctions with Bounded Number of Mistakes
- Did not Cover
  - A LOT
  - Not just P and not P
  - Many algorithmic techniques developed

NP-completeness

- “Short Proofs”
- Horde of Problems
  - 3-SAT
  - 3-coloring
  - Traveling Salesman Problem
  - Vertex Cover
  - Clique
  - Independent Set
  - Hamiltonian Cycle
  - Graph partition
  - Conductance

Dealing with NP-completeness

- Average Case Complexity
  - Some instances may have short proofs
- Approximation
  - Can approximate certain problems
  - Others resistant to approximation
- Exponential Time Algorithms
- Reductions
- Did not talk about
  - Barriers to Progress

Reductions

- Use Hard Problem to show another problem is hard
  - Reduce from hard problem
- Use Easy Problem to show another problem is easy
  - Reduce to easy problem
- NP-completeness
- Undecidiable
- Dealing with NP-completeness
- Show Cryptographic security

Cryptography

- “Sealed Envelops”
  - Coin flipping
  - Commitment
  - encryption
- Zero Knowledge Proofs

Incomputable Functions

- Different levels of infinity
  - “Cardinality” via existence of bijections
- Halting Problem, Hello Problem, Kolmogorov Complexity

Randomness

- Kolmogorov Complexity
  - Define “random” string is incompressible (unlearnable)
- Showed that “random graphs” have no large cliques or independent sets
  - Stated that we do not know how to construct these without randomness “Finding hay in a haystack”
- Randomness Used in algorithms
  - Small chance of incorrect answer.
  - We don’t think it is necessary, but cannot get rid of it
    - Polynomial Identity Testing
- Randomness in Protocols
  - Provably need it to efficiently check equality

Communication Complexity

- Rectangular Method for Lower Bounds
  - Set Intersection
  - Equality
- Upper bounds
  - Trivial algorithm
  - Fingerprints for checking equality

Learning

- Learning is
  - Prediction
  - Compression
  - Clustering
- Classification
  - With error/ without error
  - Used Linear Threshold Functions to Learn Disjuctions with Winnow [Multiplicative Updates]
- Online-Optimization
  - Experts

Experts Algorithms

- Approximate Linear Programming
- Hard-core Sets
- Boosting Learning Algorithms

Methodology

- Borrowed from mathematics
- Proof based
- Model computation mathematically
  - Ideal computers

What we did not cover

- Well, lots.
- Did not talk at all about data structures
- Did not talk much about optimizing algorithm run times

Computational/Algorithmic Lens

- Look at our world through the lens of computation
- Biology
  - Evolution (as a form of learning)
  - Sexual reproduction
- Social Sciences
  - 6 degrees of separation with navigation
  - Information Aggregation
- Economics
  - Efficiently finding equilibrium
- Physics
  - Quantum Mechanics
  - Phase Transitions