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
• Undecidable
• 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 Disjunctions with Winnow [Multipliclicative 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