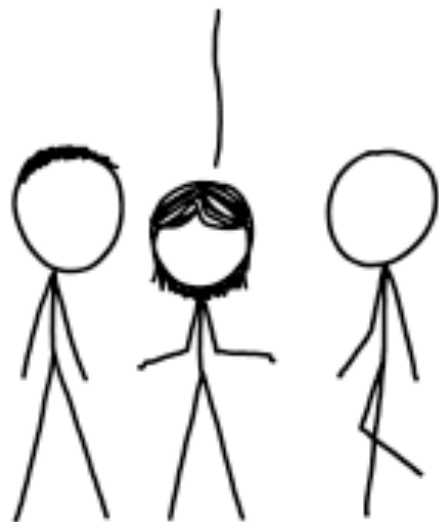


# Final Review

OUR FIELD HAS BEEN STRUGGLING WITH THIS PROBLEM FOR YEARS.



STRUGGLE NO MORE! I'M HERE TO SOLVE IT WITH *ALGORITHMS!*



SIX MONTHS LATER:

WOW, THIS PROBLEM IS REALLY HARD.

YOU DON'T SAY.



# Final Exam Coverage

Comprehensive, all topics covered  
(but with post-midterm bias)

assigned reading

slides

homework & solutions

midterm review slides still relevant, plus those  
below

# Design Paradigms

## Greedy

emphasis on correctness arguments, e.g. stay ahead, structural characterizations, exchange arguments

## Divide & Conquer

recursive solution, superlinear work, balanced subproblems, recurrence relations, solutions, Master Theorem

## Dynamic Programming

recursive solution, redundant subproblems, few do all in careful order and tabulate; OPT table (usually far superior to “memoization”)

# Examples

## Dynamic programming

Fibonacci

Making change/Stamps, Knapsack

Weighted Interval Scheduling

RNA

String Alignment

OPT function

# Examples & Concepts

## Flow and matching

Residual graph, augmenting paths, max-flow/min-cut, Ford-Fulkerson and Edmonds-Karp algorithms, (preflow-push), integrality,

## reductions to flow

e.g. bipartite matching, “baseball elimination”

# Complexity, II

## P vs NP

Big-O and poly vs exponential growth

Definition of NP – hints/certificates and verifiers

Example problems from slides, reading & hw

SAT, 3-SAT, circuit SAT, ~~vertex cover~~, ~~quadratic Diophantine equations~~,  
clique, independent set, TSP, ~~Hamilton cycle~~, coloring, max cut, knapsack

$P \subseteq NP \subseteq Exp$  (and worse)

Reduction, incl. definition(s) of (polynomial time) reduction

$SAT \leq_p$  e.g., IndpSet, Knap, ~~Ham~~, 3color: how, correctness,  $\leq_p$ , implications

Definition of NP-completeness

NP-completeness proofs

2x, 1.5x approximations to Euclidean TSP

And see how relevant  
it is to your daily life!

# Classic Nintendo Games are (NP-)Hard

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March 9, 2012

## Abstract

We prove NP-hardness results for five of Nintendo's largest video game franchises: Mario, Donkey Kong, Legend of Zelda, Metroid, and Pokémon. Our results apply to Super Mario Bros. 1, 3, Lost Levels, and Super Mario World; Donkey Kong Country 1–3; all Legend of Zelda games except Zelda II: The Adventure of Link; all Metroid games; and all Pokémon role-playing games. For Mario and Donkey Kong, we show NP-completeness. In addition, we observe that several games in the Zelda series are PSPACE-complete.



# Final Exam Mechanics

Closed book, 1 pg notes (8.5x11, 2 sides, handwritten)

(no bluebook needed; scratch paper may be handy; calculators probably unnecessary)

Comprehensive: All topics covered

assigned reading

slides

homework & solutions

# Some Typical Exam Questions

Give  $O(\ )$  bound on  $17n^*(n-3+\log n)$ , or on code `{for i=1 ...}`

True/False: If  $X$  is  $O(n^2)$ , then it's rarely more than  $n^3 + 14$  steps.

Explain why a given greedy alg is/isn't correct

Give a run time recurrence for a recursive alg, or solve a simple one

Simulate any of the algs we've studied

Give an alg for problem  $X$ , maybe a variant of one we've studied, or prove it's in NP

Understand parts of correctness proof for an algorithm or reduction

Implications of NP-completeness

Reductions

NP-completeness proofs



~~Hell's library~~ → 421 Final

**Good Luck!**

**(And please take a minute to fill out the online course evaluation.)**