CS 437 Lecture Notes

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Original lecture notes for **CS 437: Approximation Algorithms**, from Fall Quarter 2025, taught by Professor Konstantin Makarychev. This course follows ???????, ISBN ??.

Table of Contents

§1 September 16, 2025

I joined this class after this lecture.

§1.1 Macros

Below is an example algorithm using the macros in this repository. For simplicity, this algorithm computes the largest element of a fixed size array.

Algorithm 1.1: Algorithm to compute max(list)

```
input list
curmax ← list[0]
for n ∈ list do
    curmax ← max(n, curmax)
return curmax
```

There are also other environments, namely

Lemma 1.1 This is a lemma.

Proposition 1.2 and a proposition.

Definition 1.3 and a definition.

Example 1.4 These boxes are for examples.

Note These boxes are sparingly used, for asides.

Theorem 1.5 And finally, we've got the theorem.

As is standard, we can use the proof environment for proofs.

Proof. Trivial. □

§1.2 Set Cover

Definition 1.6 Set Cover Let V be some universe, with $|V| = n$. Let

$$S_1, \ldots, S_m \subseteq V \tag{1.1}$$

such that $\bigcup_i S_i = V$. Select the smallest $I \subseteq \{1, \ldots, m\}$ such that $\bigcup_{i \in I} S_i = V$.

Example 1.7 Let $V \equiv \{1, 2, 3, 4, 5\}$ and sets be pairs $\{i, j\}$ such that $i \neq j$. Then, an optimal solution is

$$I \equiv \{\{1, 2\}, \{3, 4\}, \{1, 5\}\} \tag{1.2}$$

In this case, $\mathrm{opt}(I) = 3$

Definition 1.8 The approximation factor of an algorithm is α_n if for every I of size n, we have

$$\mathrm{alg}(I) \leq \alpha_n \cdot \mathrm{opt}(I) \tag{1.3}$$

The first theorem of this course is

Theorem 1.9 There exists a polynomial time algorithm with approximation factor $\log n$.

Algorithm 1.2: Polynomial time set cover approximation algorithm

```
U_0 ← V // set of not yet covered elements in V
t ← 0 // iteration counter
for U_t ≠ ∅ do
    Select S_i from sets that maximises |S_i ∩ U_t|
    Include S_i in soln
    U_t ← U_t \ S_i
    t ← t + 1
return soln
```

1.2.1 Proof

§2 September 18, 2025