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Probabilistic Analysis
of Algorithms
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Problem Set 5

Problem 1

Give a (possibly randomized) algorithm that solves the fractional knapsack problem in expected linear time in the worst case.

Problem 2

Let $X \subseteq \mathbb{R}^d$ denote a set of N vectors. You may assume that $x_i \neq y_i$ for every $i \in [d]$ and all vectors $x, y \in X$ with $x \neq y$. Then a vector $x \in X$ is Pareto-optimal if and only if there does not exist a vector $y \in X$ with $y_i < x_i$ for all $i \in [n]$. Give an algorithm that computes the set $P \subseteq X$ of Pareto-optimal vectors in time $O(N \log N)$ for $d = 2$ and $d = 3$.

Hint: For $d = 3$, first sort the vectors in increasing order according to their first coordinate. Then insert the vectors one after another and compute the sets $S_1, \ldots, S_N$, where $S_i \subseteq X$ denotes the subset of the first i vectors from X that are Pareto-optimal with respect to the second and third coordinate. How do these sets help you to compute the set of Pareto-optimal vectors?

Problem 3

Give an implementation of the Expanding Core algorithm in Java or C++. Use your implementation to solve instances in which all profits and weights are chosen uniformly at random from $[0, 1]$ for $n = 100, 200, 300, \ldots$. How does the number of items in the core and the running time depend on n in your experiments.