MATH 487 Deterministic Operations Research

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1 Linear Programming

Definition 1.1. Linear programming: The optimization of a linear function subject to linear constraints.

Example. Suppose a starving artist is trying to plan a food budget. He is health conscious and wants a healthy diet that includes the following: at least 70 g of protein per day, at least 100 g of carbohydrates per day, exactly 15 mg of vitamin D per day, but no more than 75 g of fat per day.

Five foods to choose from (fix formatting later):

Food	Protein	Carbohydrates	Vitamin D	Fat	Cost
Hamburger	10g/oz	2g/oz	.5mg/oz	8g/oz	\$0.20/oz
Milk	2g/oz	3 g/oz	4mg/oz	2g/oz	\$0.02/oz
Cereal	3g/oz	23g/oz	2mg/oz	1g/oz	\$0.10/oz
Ch. N S	2g/oz	2g/oz	0 mg/oz	0.5g/oz	\$0.03/oz
Eggs	6g/egg	4g/egg	1mg/egg	5g/egg	\$0.10/egg

Question: How can he meet dietary goals while minimizing cost?

Answer. Set up **decision variables**:
H, M, C, CNS, and E are oz (or number) per day

Constraints:
Protein: $p = 10H + 2M + 3C + 2CNS + 6E \geq 70$
Carbs: $c = 2H + 3M + 23C + 2CNS + 4E \geq 100$
Vitamin D: $0.5H + 4M + 2C + E = 15$
Fat: $f = 8H + 2M + 1C + 0.5CNS + 5E \leq 75$
Nonnegativity: $H, M, C, CNS, E \geq 0$

Subject to these requirements, we wish to minimize cost:

$$cost = 20H + 2M + 10C + 3CNS + 10E$$

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Definition 1.2. Let $f : \mathbb{R}^n \to \mathbb{R}$ be a function of n variables, then f is called linear $\iff$ f is of the form

$$f(x_1, x_2, \ldots x_n) = a_1x_1 + a_2x_2 + \cdots + a_nx_n + b_0$$

for some constraints

$$a_1, a_2, \ldots a_n \text{ and } b_0$$

Definition 1.3. A linear equation is an equation of the form $f(x_1, \ldots, x_n) = a$ constant.

Definition 1.4. A linear inequality is an inequality of the form $f(x_1, \ldots, x_n) \leq$ a constant, or $f(x_1, \ldots, x_n) \geq$ a constant.

Definition 1.5. A linear constraint is either a linear equation or a linear inequality.

Definition 1.6. A linear program is the optimization of a linear function subject to linear constraints.