IE 426
Optimization models and applications

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Evaluation

Homework:	20%	(four)
Quiz #1:	10%	(≈ Sep 25)
Quiz #2:	15%	(≈ Nov 5)
Case study:	25%	
Final exam:	30%	

Case studies

Groups of three-four people

- study an Optimization problem,
- propose a model, and
- solve it using a tool[1] of their choice.

[1] An optimization tool…

Material

- Select chapters of "Introduction to Operations Research" by F.S. Hillier and G.J. Lieberman, McGraw-Hill: New York, NY, 1990;
- Select chapters of "Introduction to Mathematical Programming: Applications and Algorithms", Volume 1, by W.L. Winston and M. Venkataramanan;
- Select chapters of "Operations Research: Applications and Algorithms" by Wayne L. Winston, PWS-Kent Pub. Co., 1991;
- three chapters of a book on modeling by Robert Fourer, available for download.
- modeling language: "AMPL: A Modeling Language for Mathematical Programming" by Robert Fourer, David M. Gay, and Brian W. Kernighan.
- Some handouts.

Modeling languages

They are similar, and each has its own pros/cons. All have limited version available to students.

- Mosel: very nice Graphical User Interface (GUI)
- AMPL: preferred. No GUI, but I know it better (read: I can help)
- GAMS: Has version with even nicer GUI (Aimms)

Optimization models...

- Optimization aims at finding the best configuration of processes, systems, products, etc.
- It relies on a theory developed mostly in the past 50 years
- Applying Optimization in an industrial, financial, logistic context yields a better use of budget/resources ($$$) or a higher revenue ($$$)

...and applications

Source: `http://www.informs.com`
(see also `http://www.ScienceOfBetter.org`)

yr	company	result
86	Eletrobras (hydroelectric energy)	43M$ saved
90	Taco Bell (human resources)	7.6M$ saved
92	Harris semicond. prod. planning	50% → 95% orders "on time"
95	GM – Car Rental	+50M$
96	HP printers — re-designed prod.	2x production
99	IBM — supply chain	750M$ saved
00	Syngenta — corn production	5M$ saved

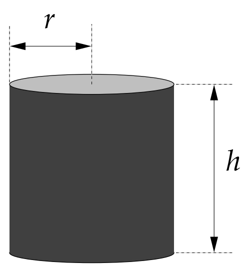
An example

- You work at a company that sells food in glass containers only. Today, your boss has a bright idea! The **tin can**®. It's a cylinder made of tin.
- The can must contain $V = 20$ cu.in. (11 fl.oz., 33 cl)
- Cut and solder tin foil to produce cans
- Tin (foil) is expensive, use as little as possible

Boss: "What is the ideal can? Tall and thin or short and fat?"

You: A cylinder with volume V using as little tin as possible.

Example



If we knew radius r and height h,

- the volume would be $\pi r^2 h$
- qty of tin would be $2\pi r^2 + 2\pi r h$

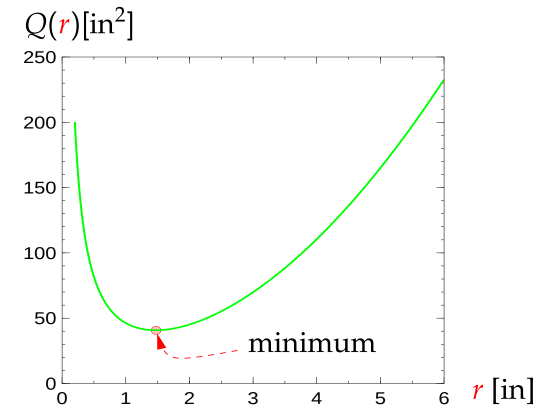
$\pi r^2 h$ must be $V = 20\text{in}^3 \Rightarrow h = \frac{V}{\pi r^2}$

Rewrite the quantity of tin as $Q(r) = 2\pi r^2 + 2\pi r \frac{V}{\pi r^2}$, or

$$Q(r) = 2\pi r^2 + \frac{2V}{r}$$

$\Rightarrow$ Find the minimum of $Q(r)$!

Minimize the quantity of tin



$r =$ **1.471 in** $\quad h = \frac{V}{\pi(1.471)^2} = 2.942$ in

Aims of this course

- model Optimization problems
- so that they can be solved
- learn a modeling language
- apply modeling languages to real-world problems

Your first Optimization model

Variables	r: ray of the can's base h: height of the can
Objective	$2\pi r h + 2\pi r^2$ (minimize)
Constraints	$\pi r^2 h = V$ $h > 0$ $r > 0$

Optimization Models, in general, have:

Variables: Height and radius, number of trucks, . . . The *unknown* (and desired) part of the problem (one thing your boss cares about).

Constraints: Physical, explicit ($V = 20\text{in}^3$), imposed by law, budget limits. . . They define **all** and **only** values of the variables that give possible solutions.

Objective function: what the boss really cares about. Quantity of tin, total cost of trucks, total estimated revenue, . . . a function of the variables

Schedule

- Models, convexity, relaxations
- Linear Programming (and Optimization on graphs)
- Integer Programming (and logical constraints)
- Nonlinear and Stochastic Programming

Reading for today

- Chapter 1 of Fourer's book (online), **or**
- Winston, chapter 1, **or**
- Winston & Venkataramanan, chapter 1, **or**
- Hillier & Lieberman, chapter 2.

Next lecture:

- Convexity
- Relaxations
- Lower bounds, Upper bounds