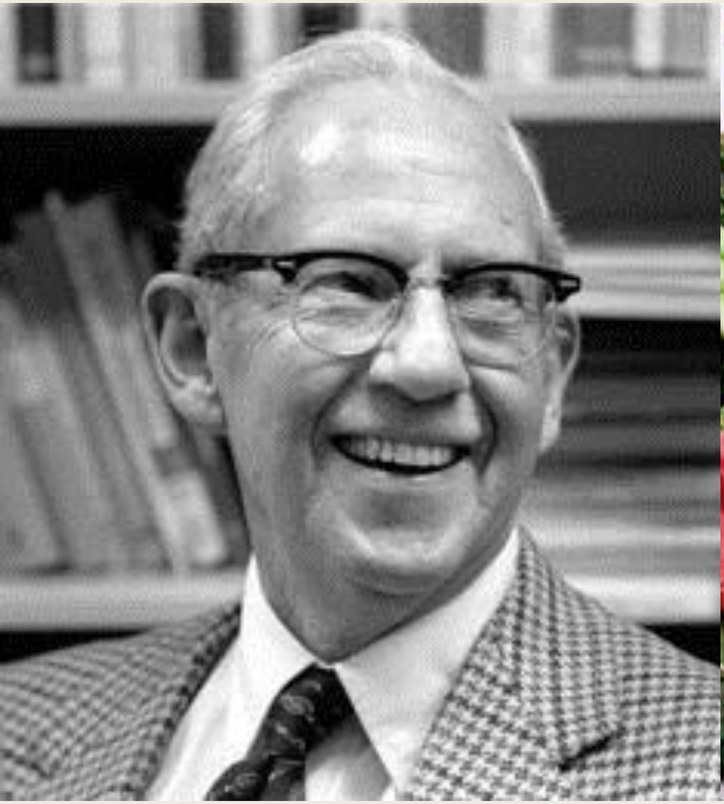
Design Optimization

MAE598/494
Arizona State University
Spring 2015

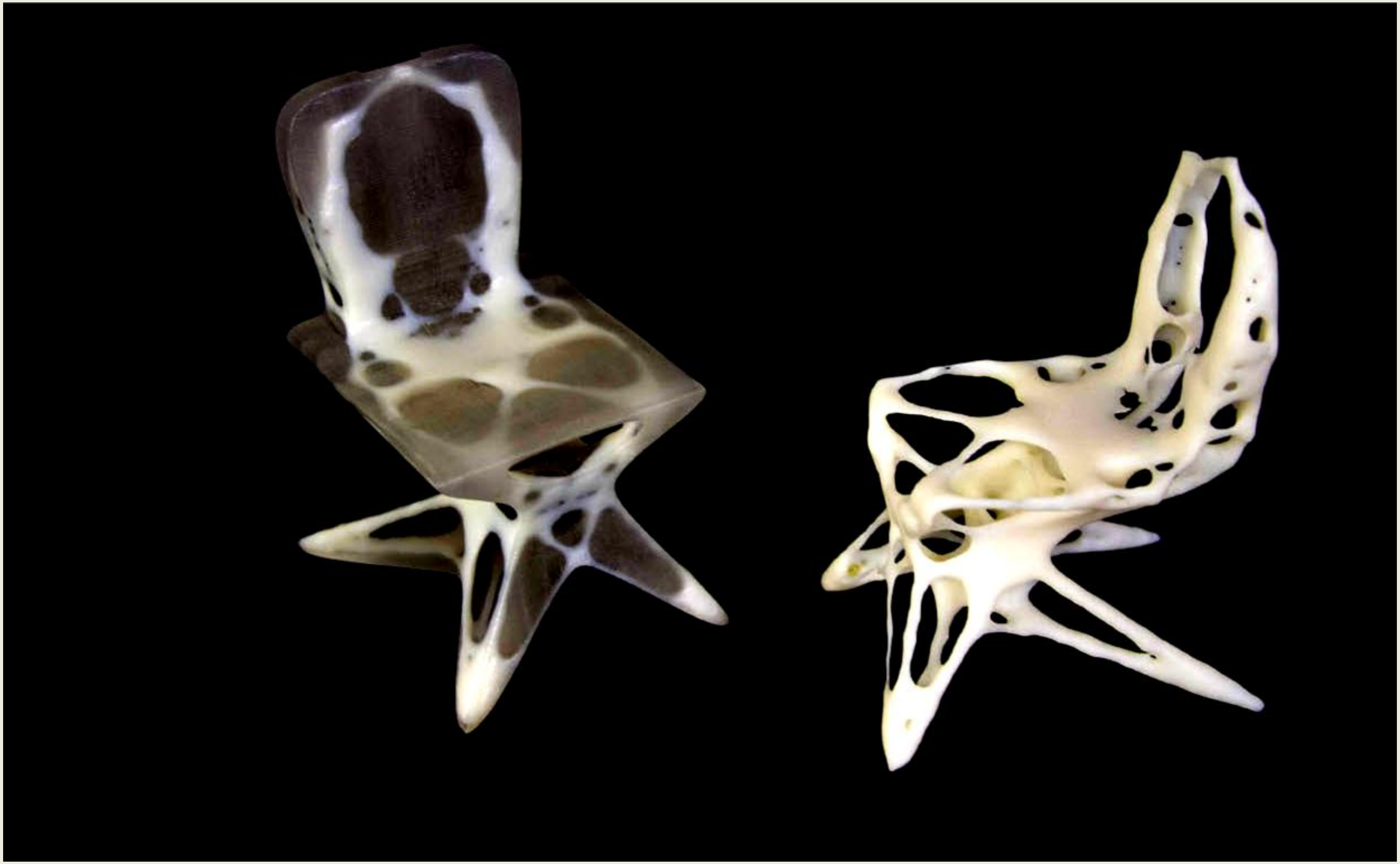
WWII: Minimizing travel distances of transport ships, by avoiding German U-boats – T.C. Koopmans

The Stigler diet: How much of each food should be eaten to satisfy the nutrition requirements, to minimize the living cost?

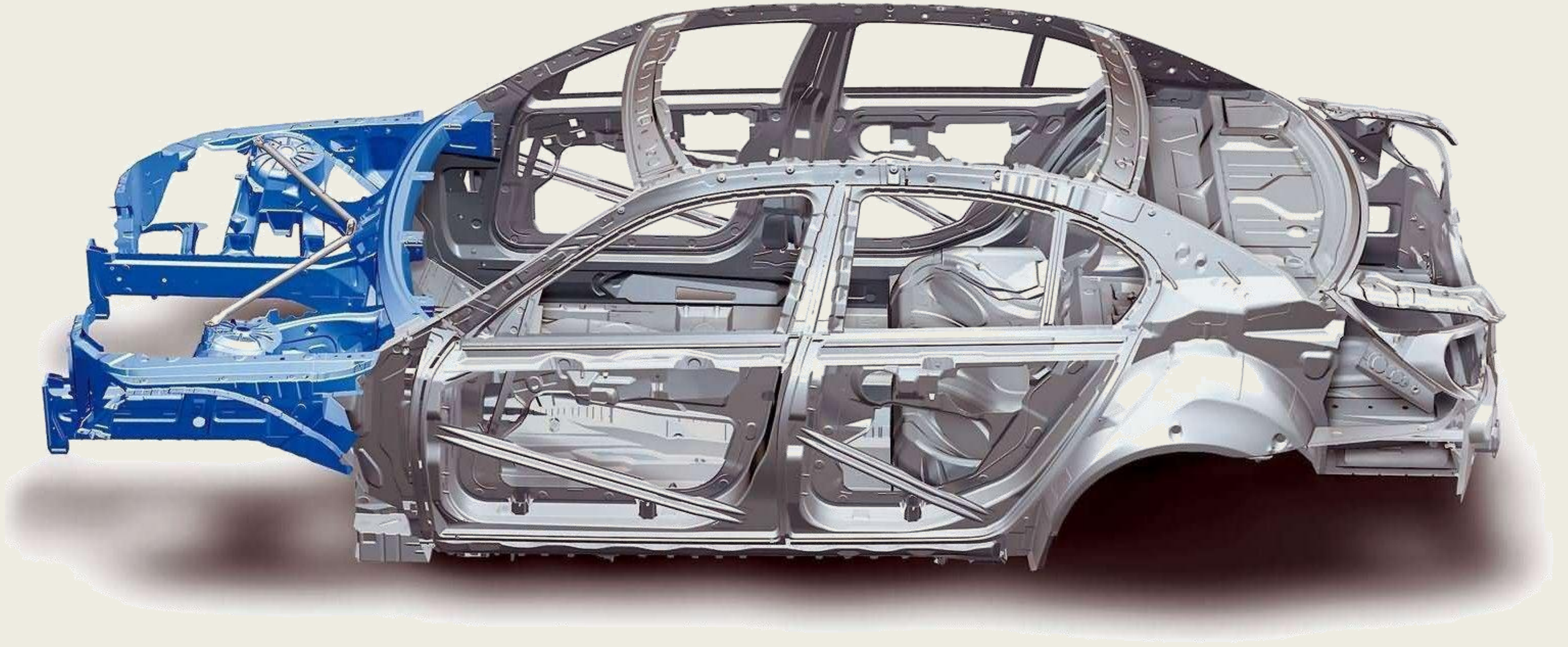


George Stigler, 1982 Nobel Laureate in economics

Topology optimization: Optimal material allocation for given loads



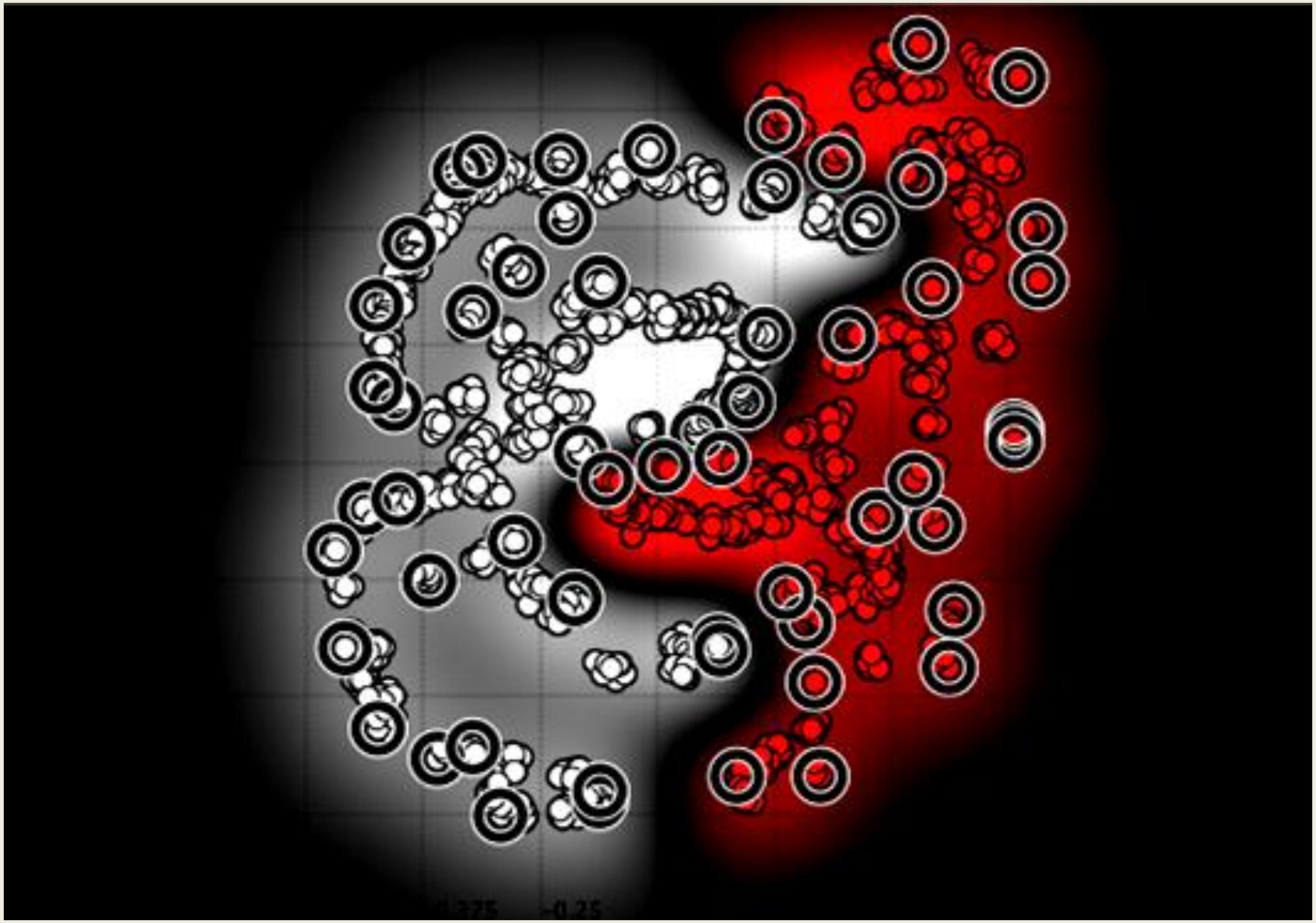
Topology optimization: Optimal material allocation for given loads



Source: bp.blogspot.com

Classification: Find the largest margin between two classes.

Applications in face & voice recognitions, recommender systems, email filtering, …



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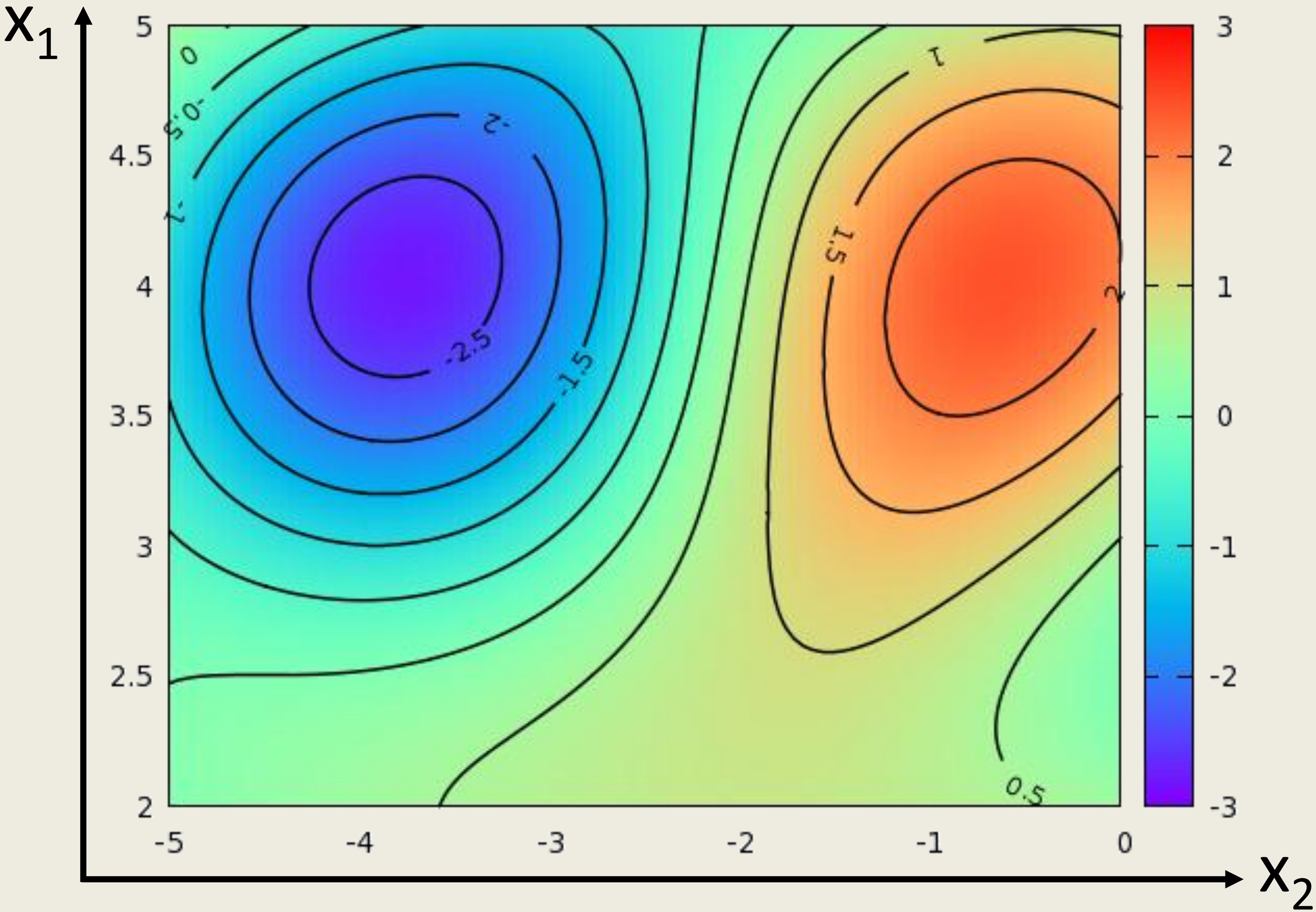
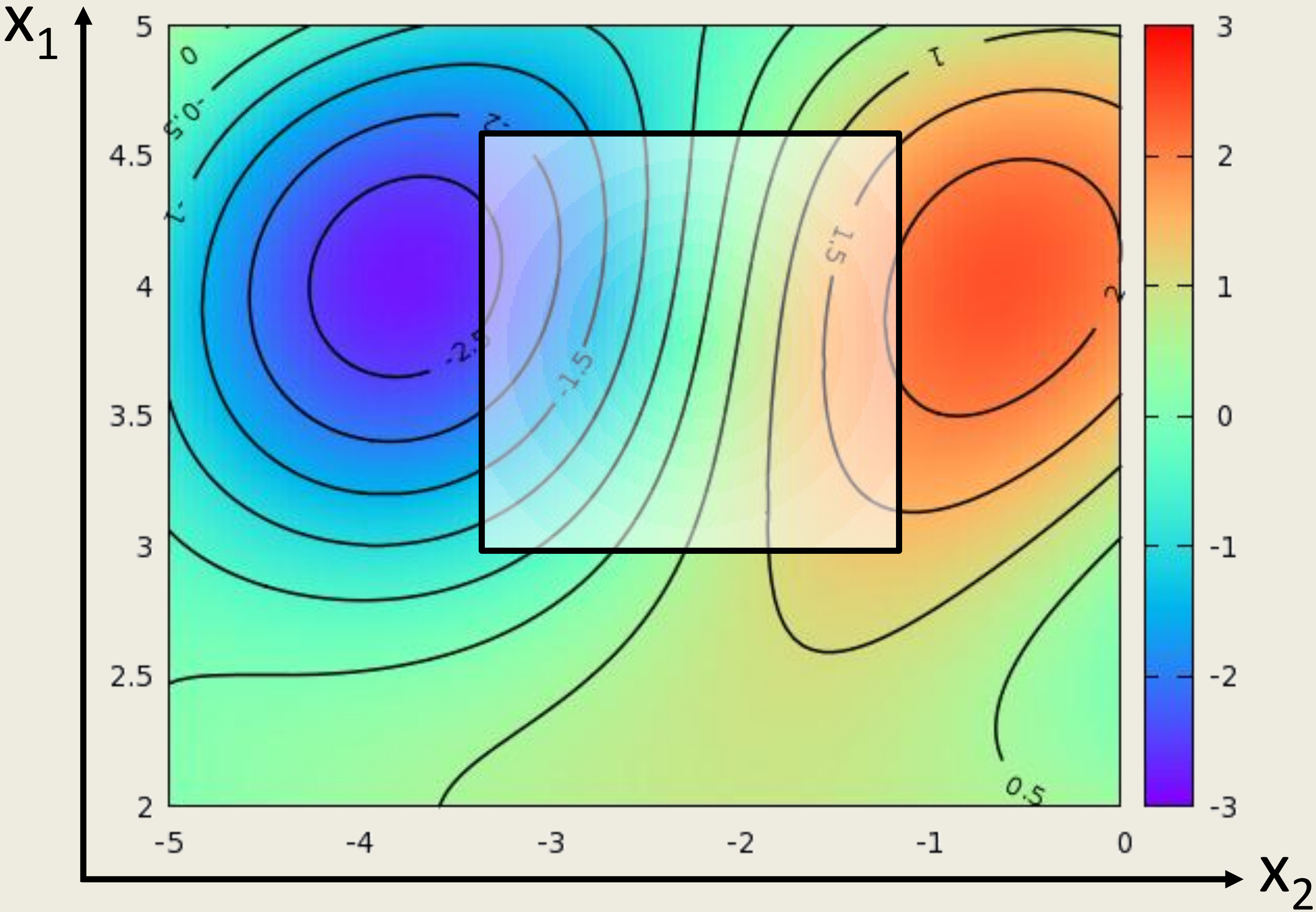
What’s in common among these examples?

Optimization is about making the “best” decision

Variables and the Objective



Variables, Objective & Constraints



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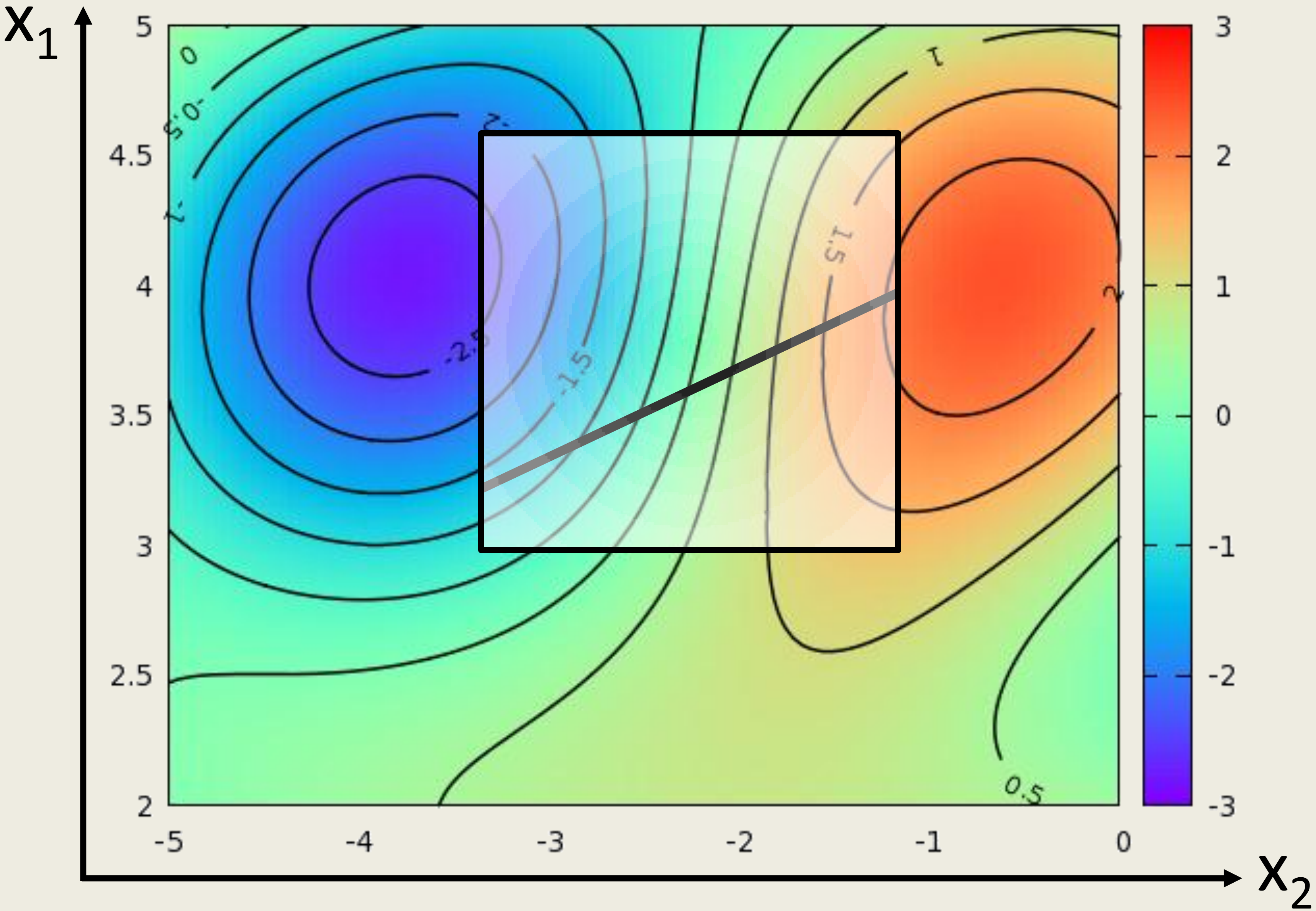
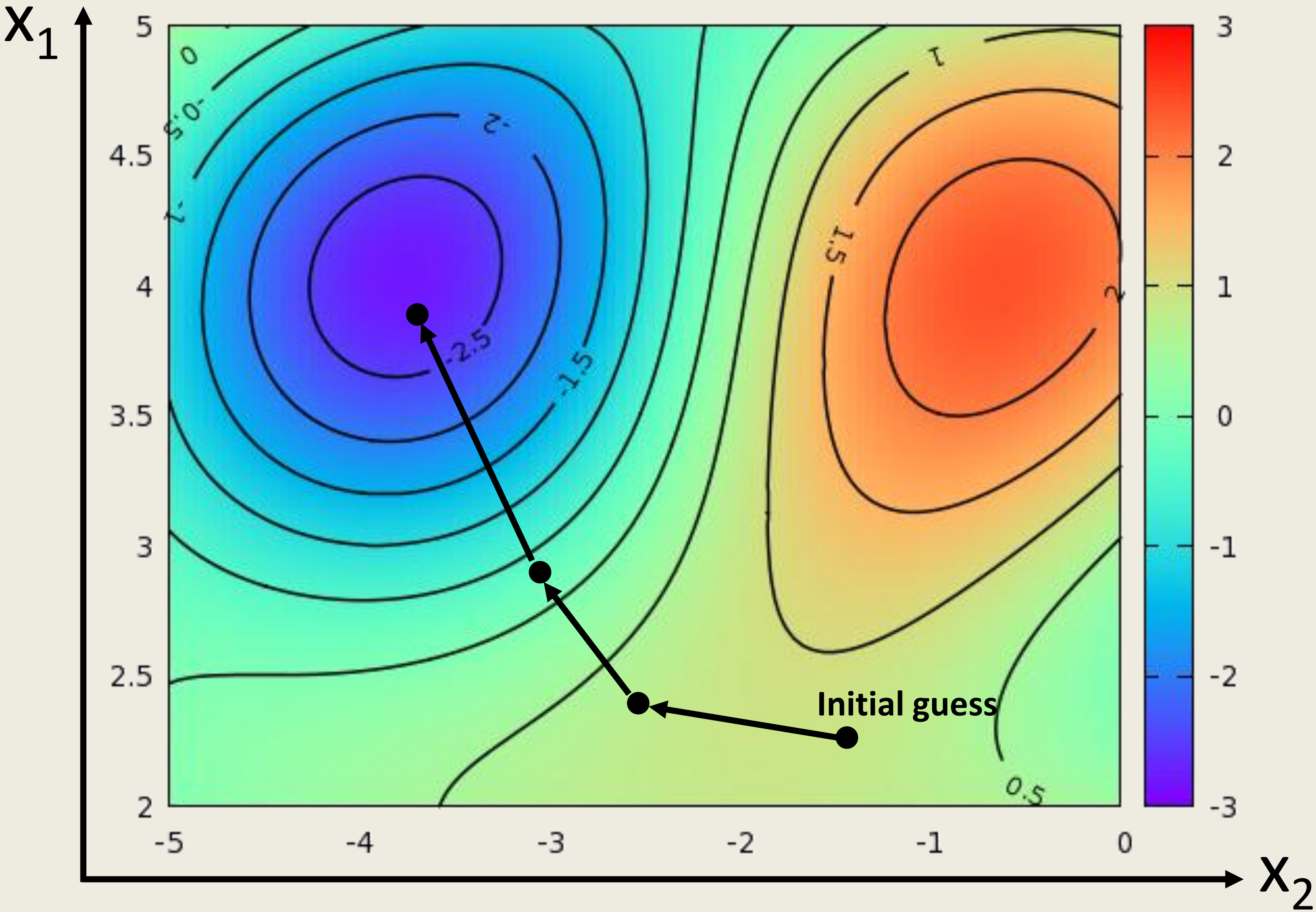


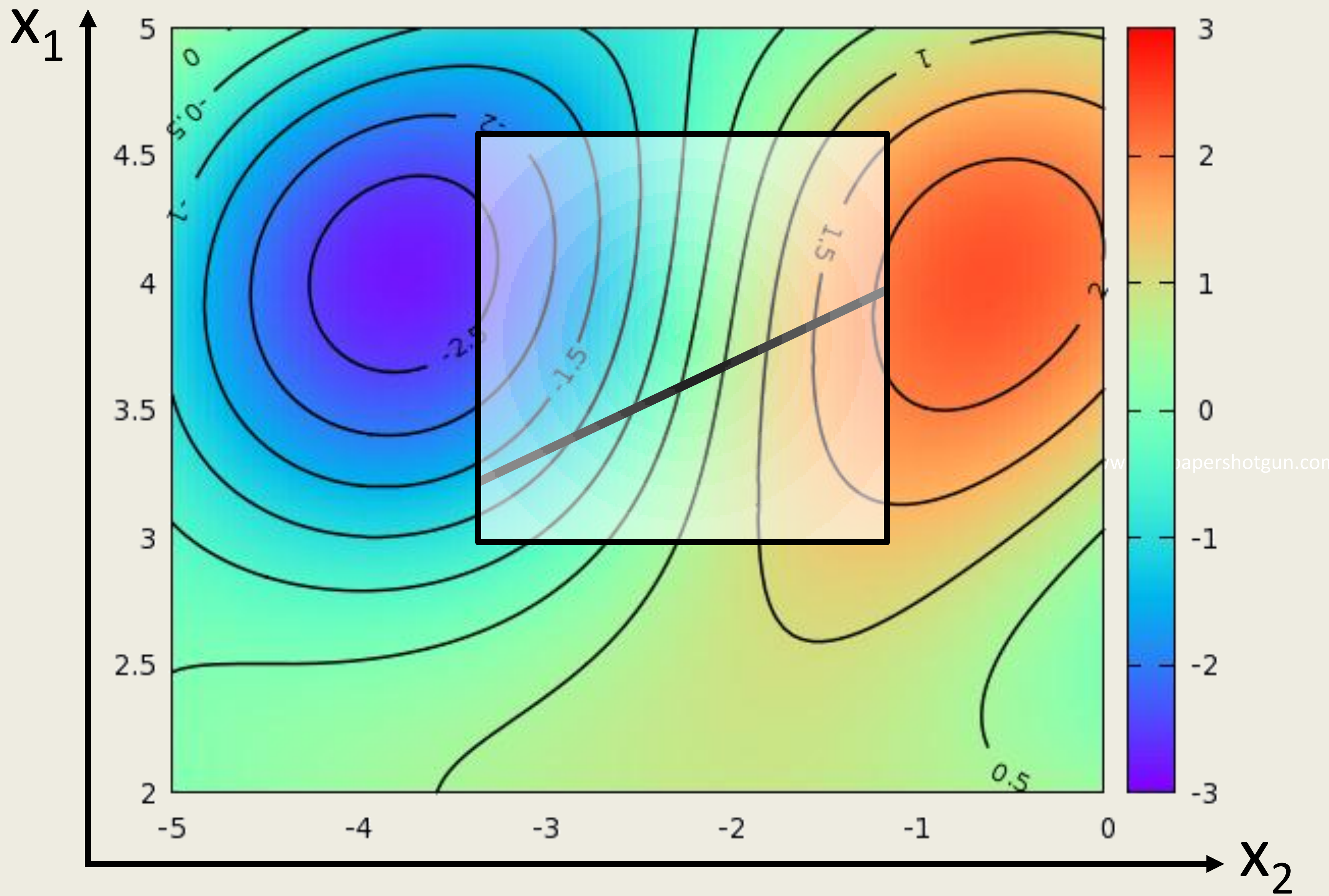
Optimization is an iterative process

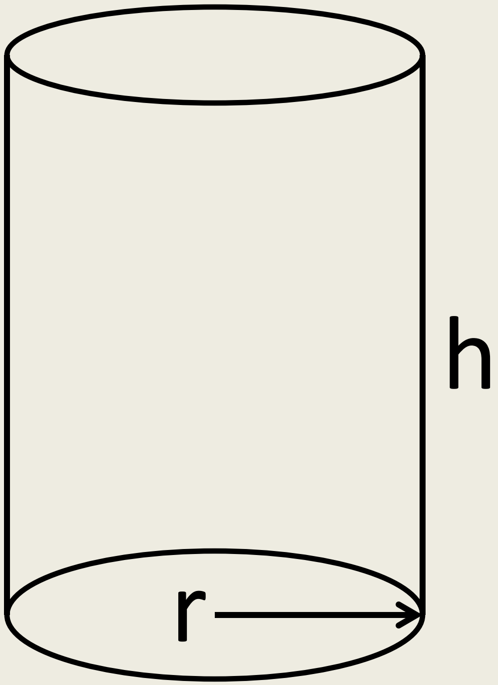


Negative null form

Minimize: $f(\mathbf{x})$ w.r.t. $\mathbf{x}$

Subject to: $\mathbf{h}(\mathbf{x}) = 0$, $\mathbf{g}(\mathbf{x}) <= 0$





Exercise: How should a cola can look like, if we want to minimize material cost?

$$\min_{r,h} \quad 2\pi r^2 + 2\pi r h$$
$$\text{subject to:} \quad \pi r^2 h = V$$

Let V = 355 ml,

solve to have: r = 3.84 cm, h = 7.67 cm

* shorter and wider than a real cola can

“AutoZip” considers launching a zipcar service in Phoenix area with a fleet of autonomous vehicles. Help the company to make a business plan.

What is the objective?

What are the variables?

What are the constraints?

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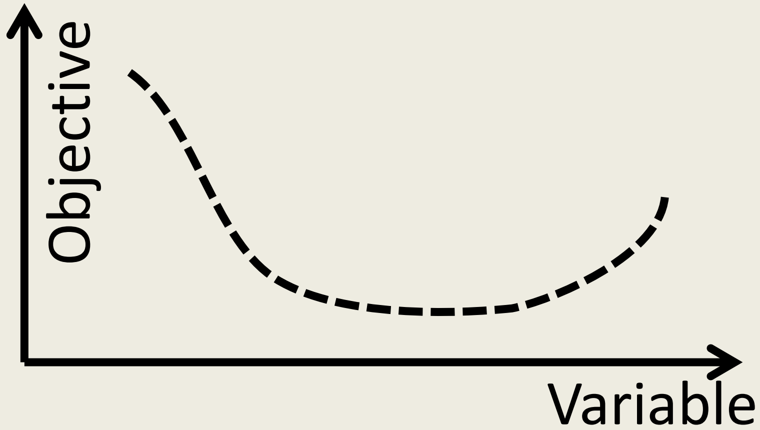
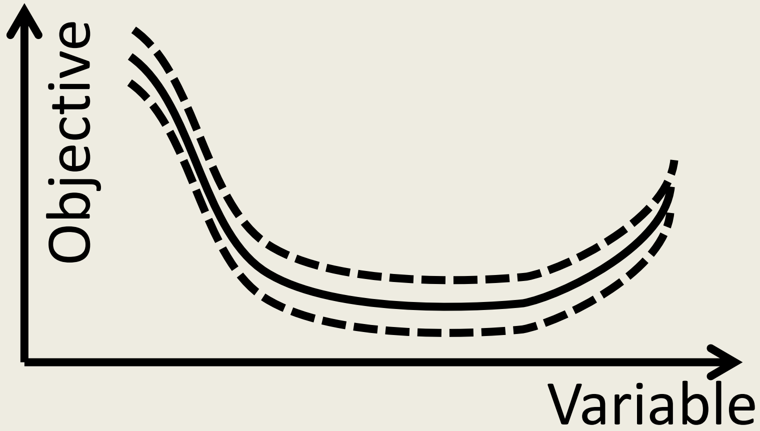
What are the assumptions?

Common issues in design optimization

No analytical forms for the objective and/or constraints

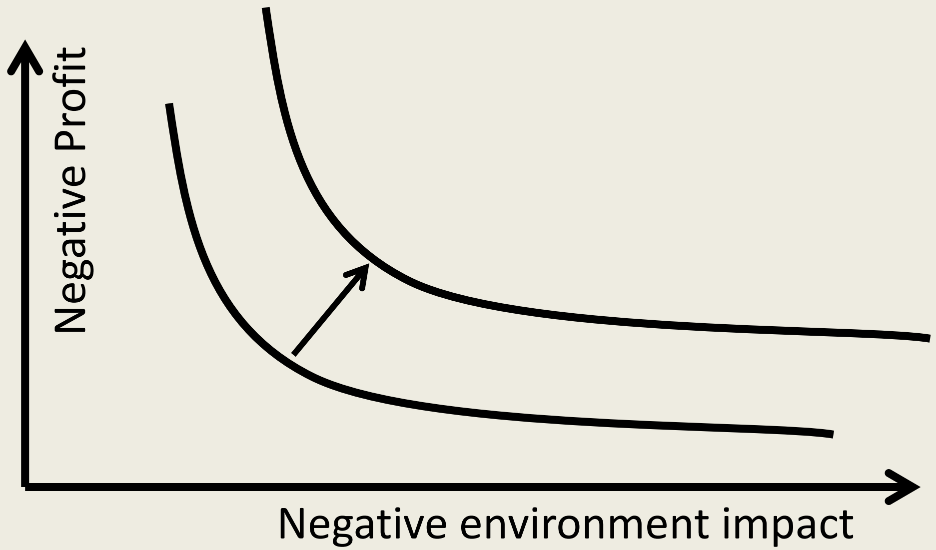


Probabilistic responses

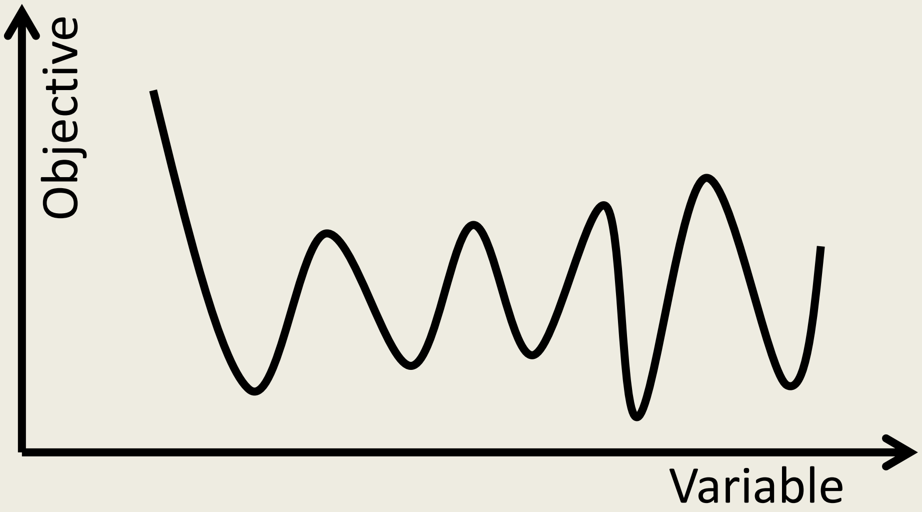


Common issues in design optimization

Multiple objectives



Multiple local solutions and other computational issues



This course will focus on:

* Theories and gradient-based algorithms
- KKT conditions, Gradient and Newton’s methods, SQP

* Derivative-free algorithms

* Statistical modeling

- Five Homework assignments 20% (calculations, proofs, coding)
  Please turn in at the beginning of the class.
  20% penalty on late homework w/o valid excuse.
- Two midterm exams 15% each (NO final)
- Team project (peer evaluated) 40%
- Class participation 10%

- Office hours: 9 – 12pm Wed., GWC464
- Office hours in GWC460 for the first week
- Meetings for team projects

Important dates:
Jan 29: Proposal due
Feb 12: Midterm 1
Mar 05: Progress report due
Apr 14: Midterm 2
May 01: Final report due

Book:

Principles of Optimal Design, Papalambros and Wilde

Convex Optimization, Stephen Boyd
PDF version is available online

Alternative courses:

Linear Programming
Convex Optimization
Dynamic Programming
Structure Optimization

FAQ

Q: Is this class time-consuming?
A: Yes. 10 -15 hours per week, off class.

Q: What does the score look like?
A: Most people get A- and A.

Q: Anything I should know by now?
A: Basic calculus, linear algebra, MATLAB

Q: Is the class worth taking?
A: Yes, if you are an engineer and haven't learned optimization.

Please decide whether you want to take this class or not before next Tuesday.

“Crossing the desert” (project EUREKA, problem 97)

An unlimited supply of gasoline is available at one edge of a desert 1000 miles wide, but there is no source in the desert itself.
A truck can carry enough gasoline to go 500 miles (this is called the "load"), and it can build its own refueling stations at any spot along the way. What is the minimum amount of gasoline (in loads) the truck will require in order to cross the desert?