

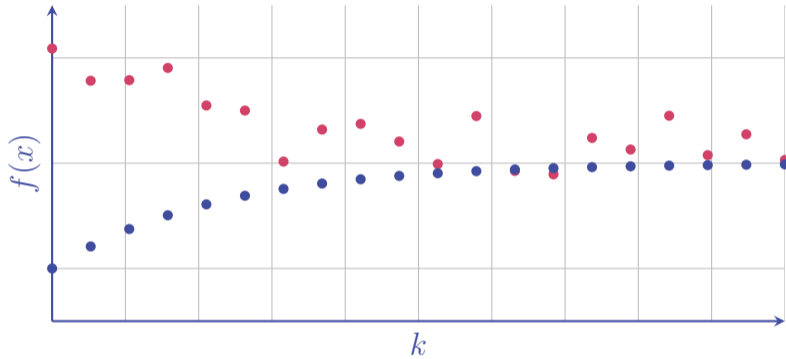
EPOC Mini-workshop 2017

A deterministic algorithm for multistage stochastic programming problems

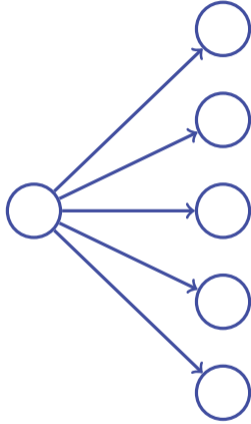
Regan Baucke, Tony Downward, Golbon Zakeri

EPOC, The University of Auckland

`r.baucke@auckland.ac.nz`







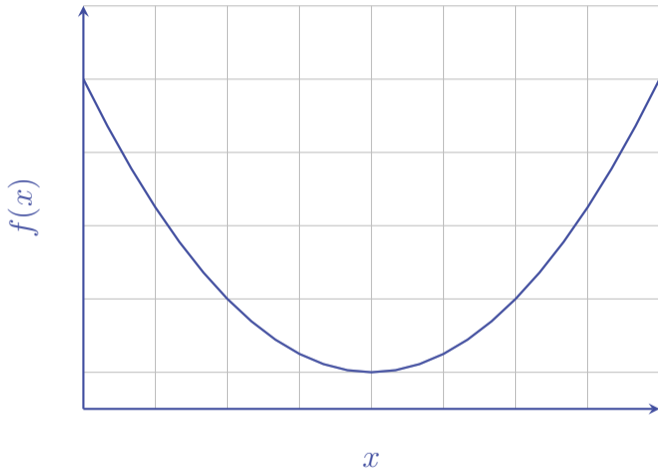
Kelley's Cutting Plane

The upper-bound function

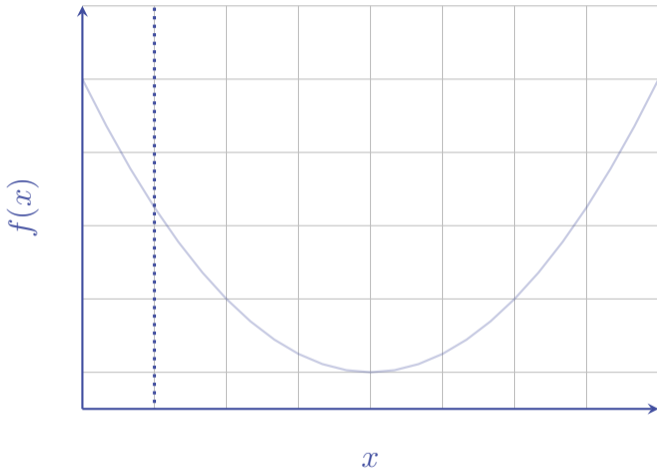
The algorithm

Conclusions

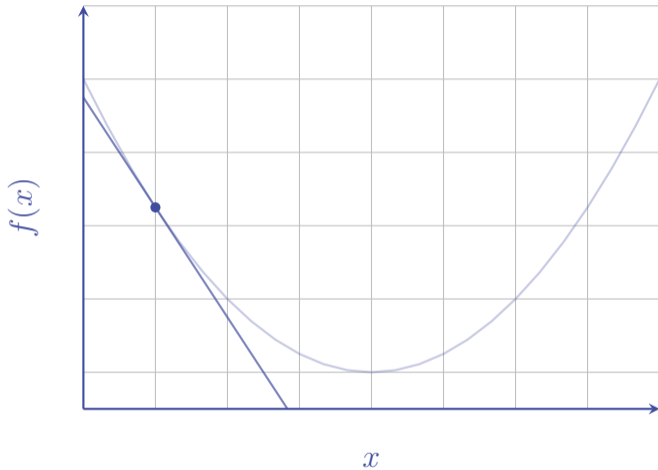
$$f^* = \min_{x \in \mathcal{X}} f(x)$$



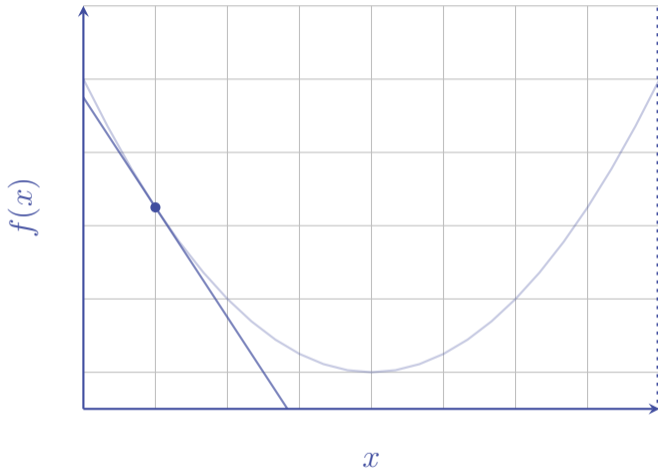
Kelley's Cutting Plane | Quick run-down



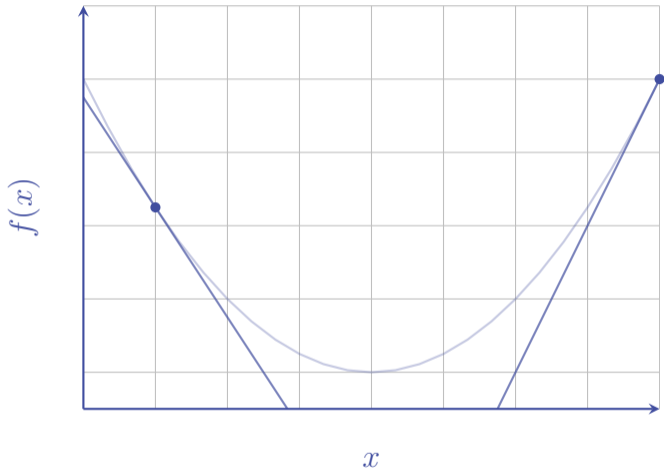
Kelley's Cutting Plane | Quick run-down



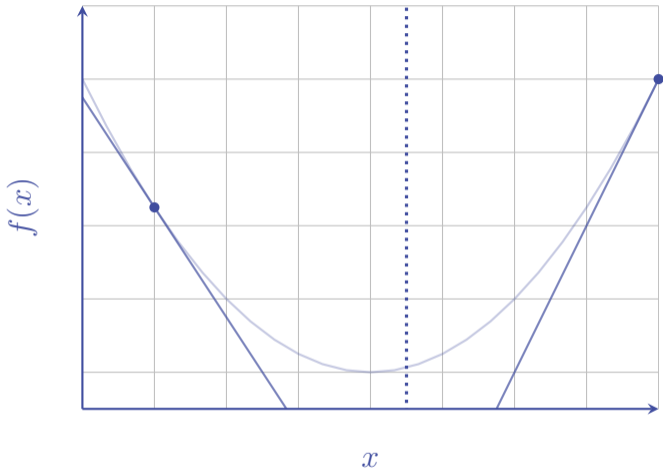
Kelley's Cutting Plane | Quick run-down



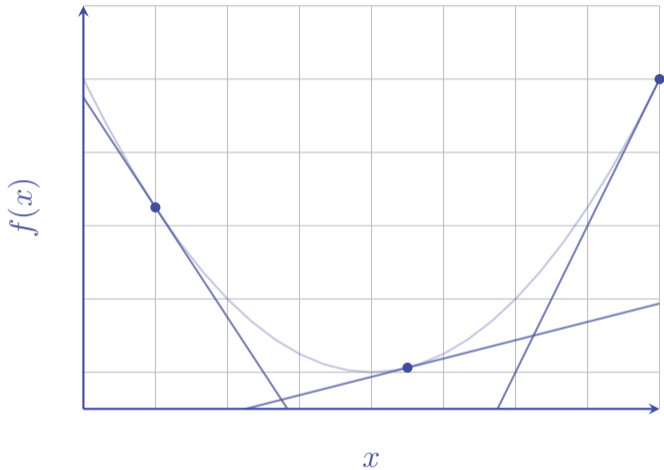
Kelley's Cutting Plane | Quick run-down



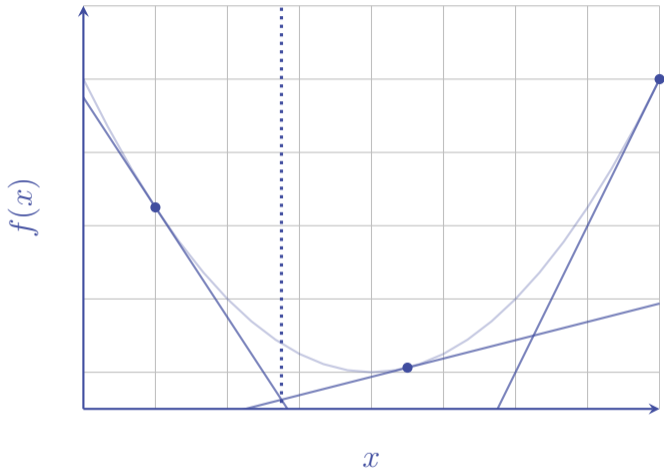
Kelley's Cutting Plane | Quick run-down



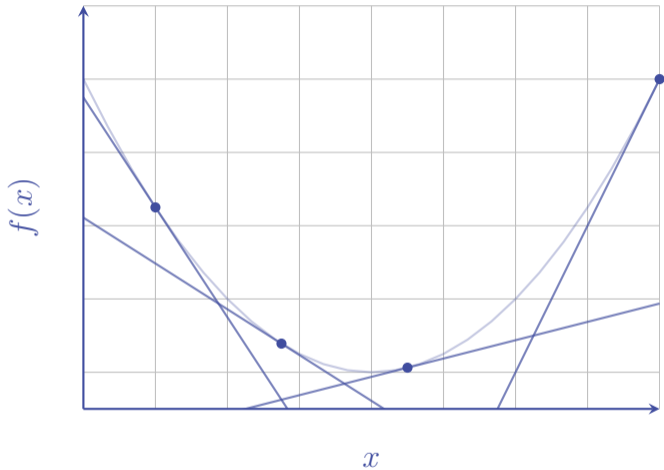
Kelley's Cutting Plane | Quick run-down



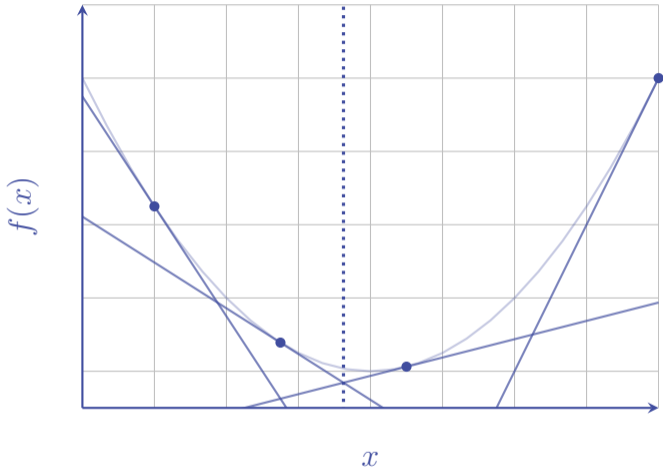
Kelley's Cutting Plane | Quick run-down



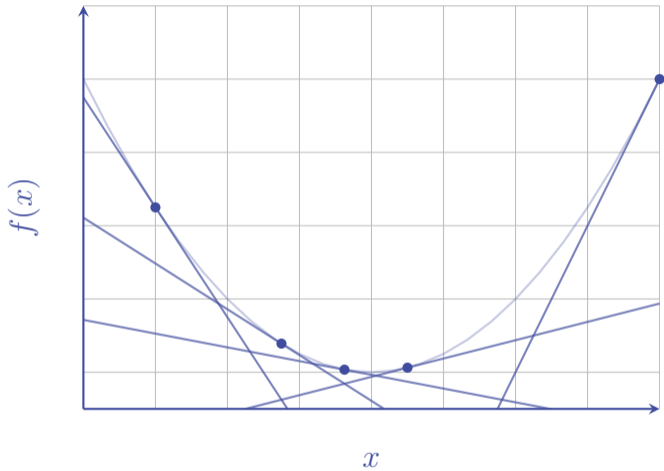
Kelley's Cutting Plane | Quick run-down



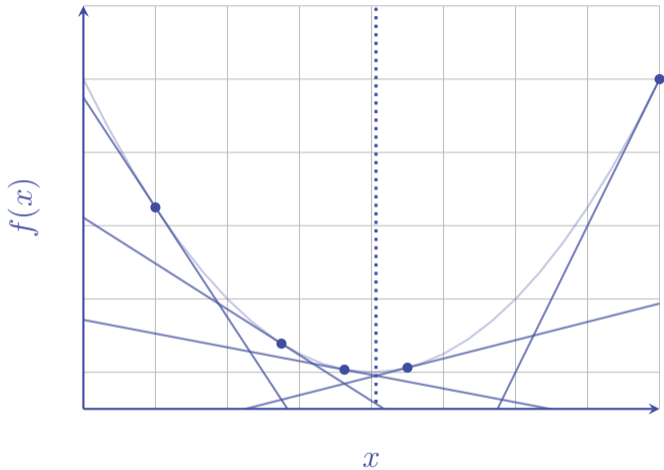
Kelley's Cutting Plane | Quick run-down



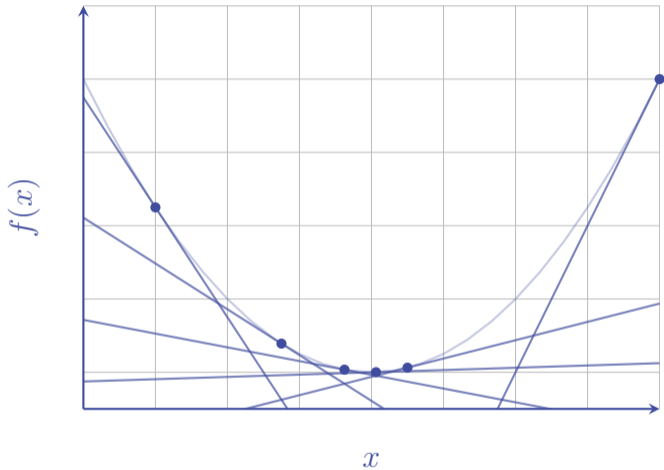
Kelley's Cutting Plane | Quick run-down



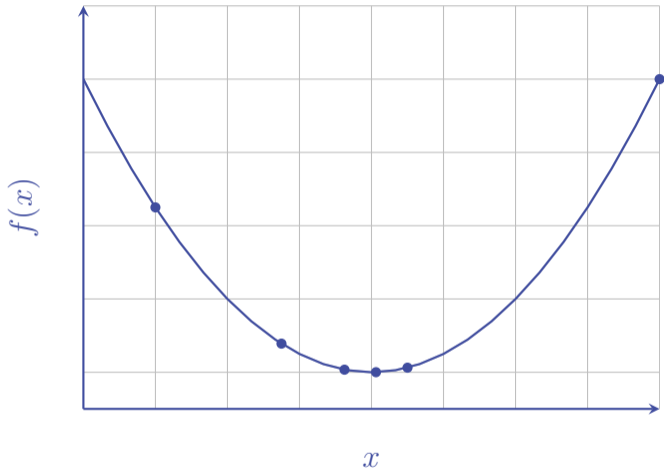
Kelley's Cutting Plane | Quick run-down



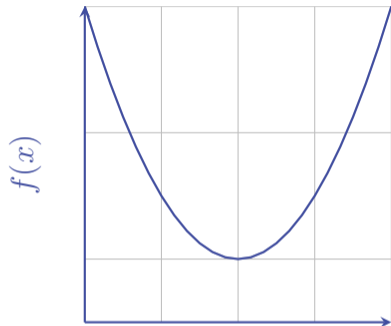
Kelley's Cutting Plane | Quick run-down



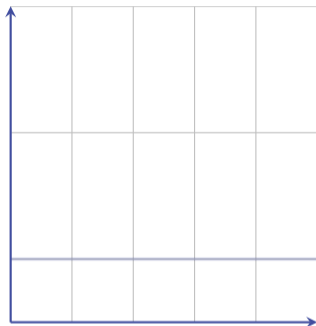
Kelley's Cutting Plane | Quick run-down



Kelley's Cutting Plane | Quick run-down

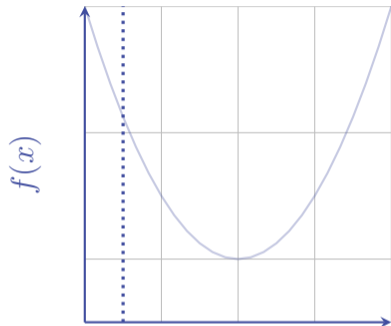


x

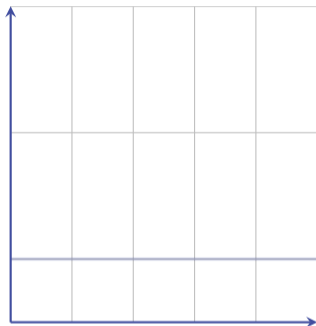


k

Kelley's Cutting Plane | The lower-bound

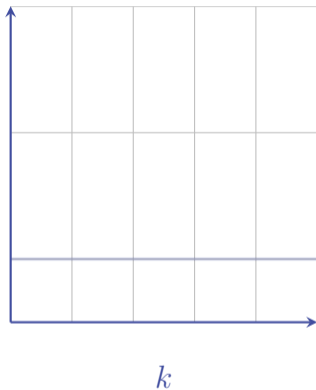
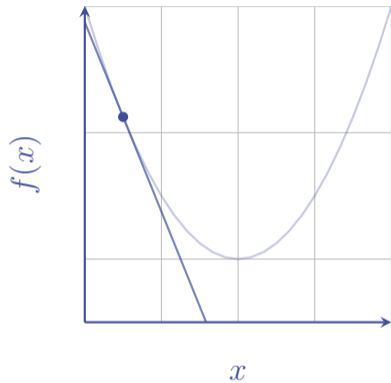


x

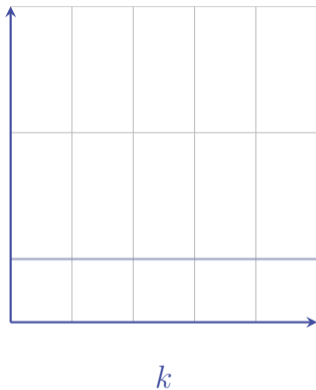
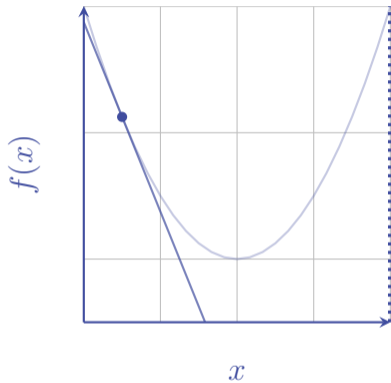


k

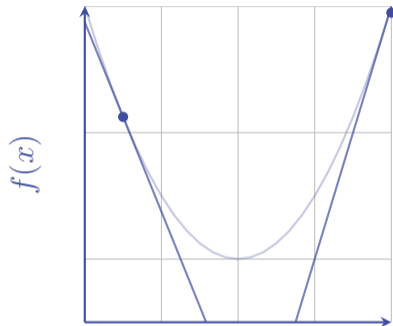
Kelley's Cutting Plane | The lower-bound



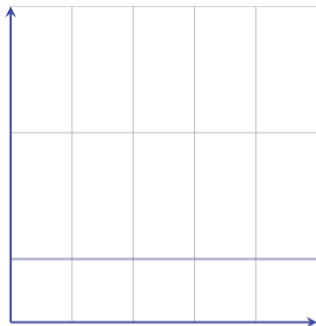
Kelley's Cutting Plane | The lower-bound



Kelley's Cutting Plane | The lower-bound

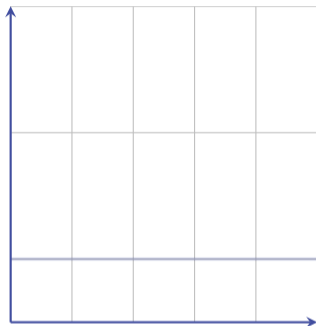
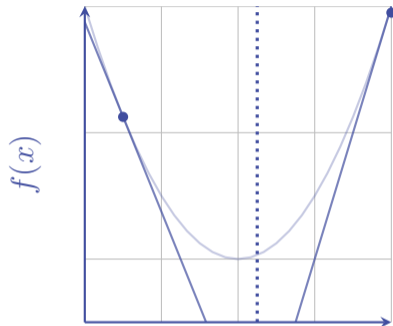


x

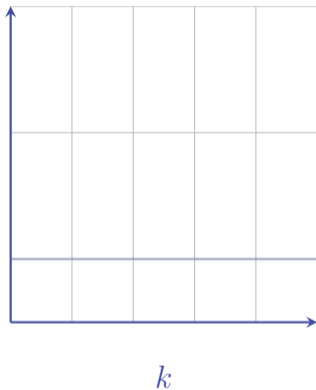
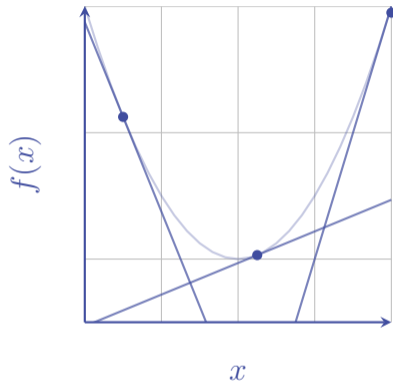


k

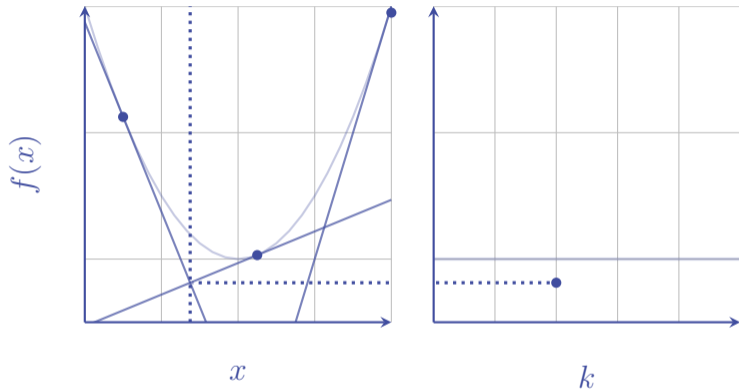
Kelley's Cutting Plane | The lower-bound



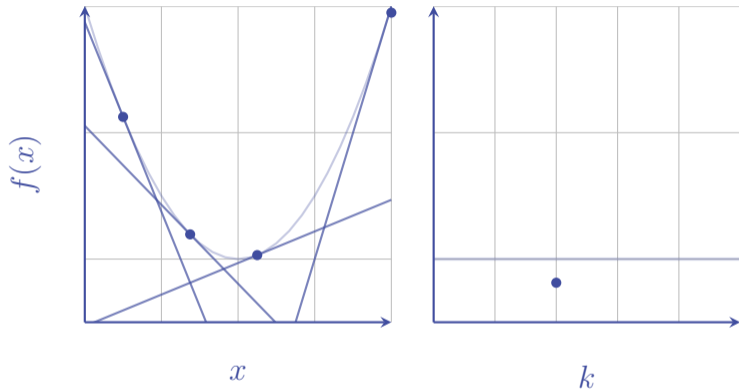
Kelley's Cutting Plane | The lower-bound



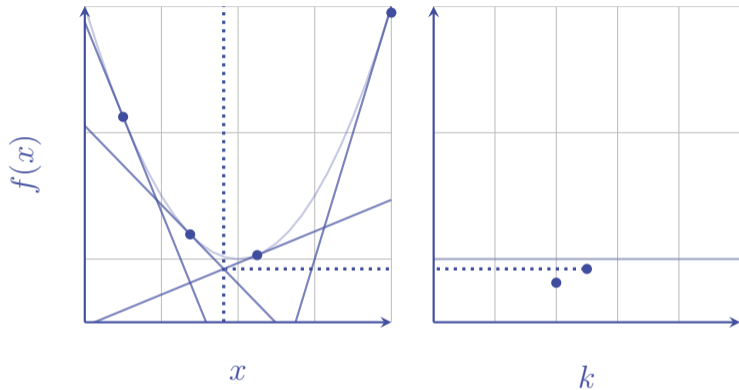
Kelley's Cutting Plane | The lower-bound



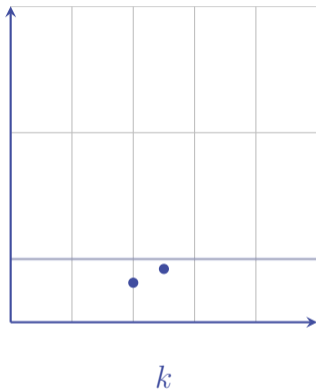
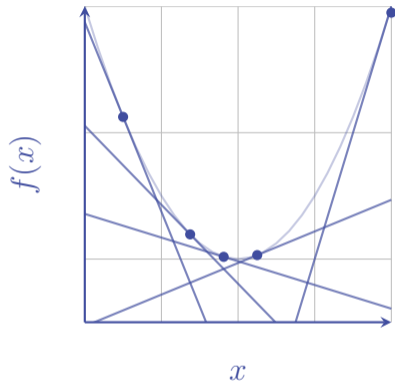
Kelley's Cutting Plane | The lower-bound



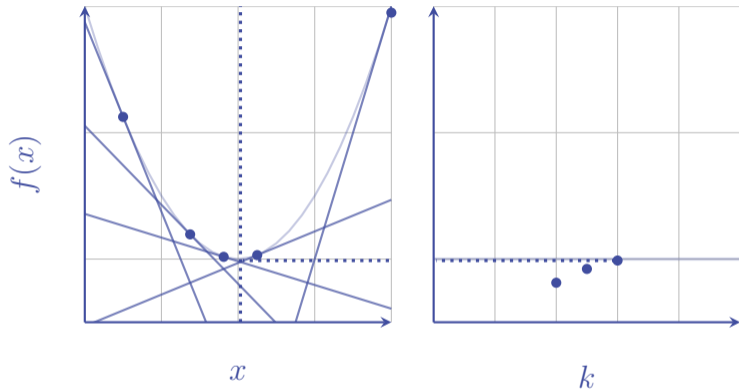
Kelley's Cutting Plane | The lower-bound



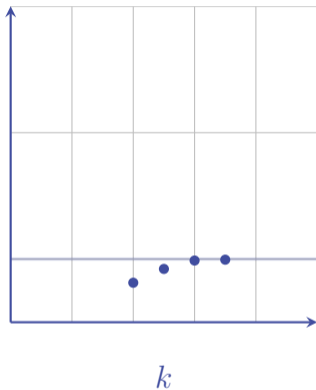
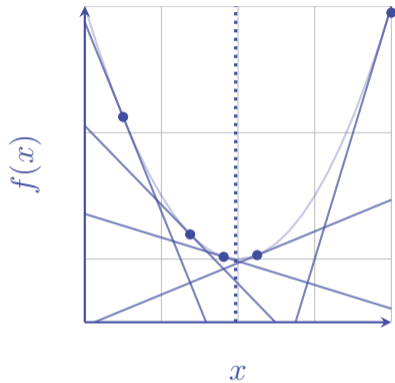
Kelley's Cutting Plane | The lower-bound



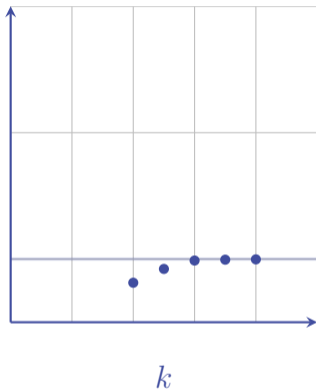
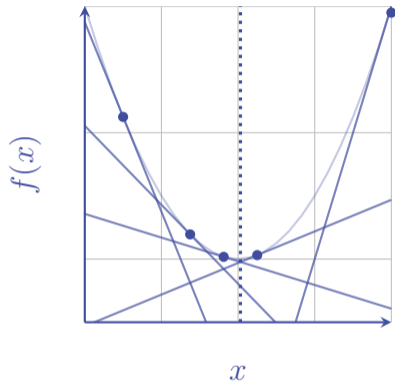
Kelley's Cutting Plane | The lower-bound



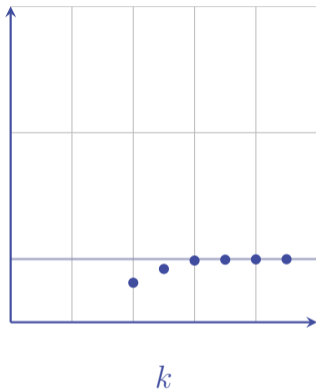
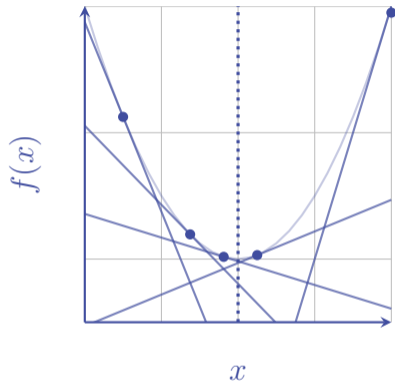
Kelley's Cutting Plane | The lower-bound



Kelley's Cutting Plane | The lower-bound

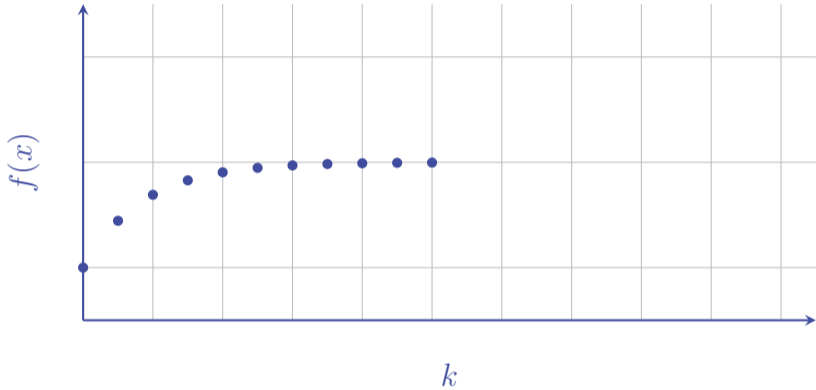


Kelley's Cutting Plane | The lower-bound

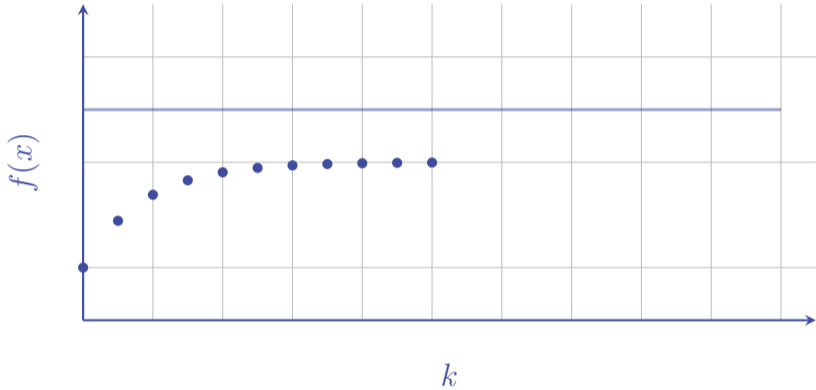


Kelley's Cutting Plane | The lower-bound

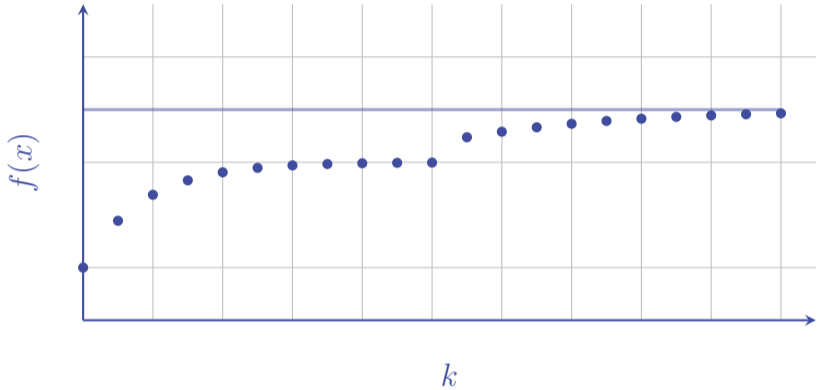
We don't know the **true**
minimum



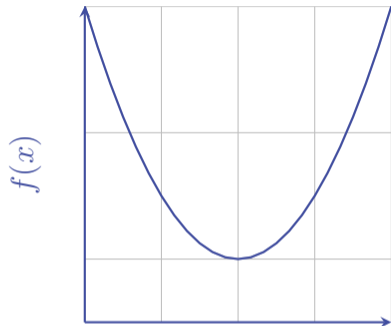
Kelley's Cutting Plane | The lower-bound



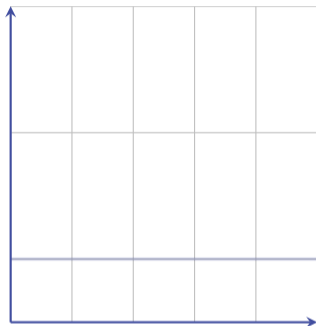
Kelley's Cutting Plane | The lower-bound



Kelley's Cutting Plane | The lower-bound

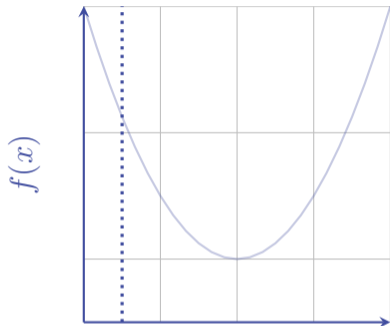


x

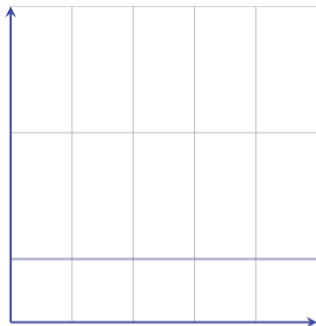


k

Kelley's Cutting Plane | A basic upper-bound

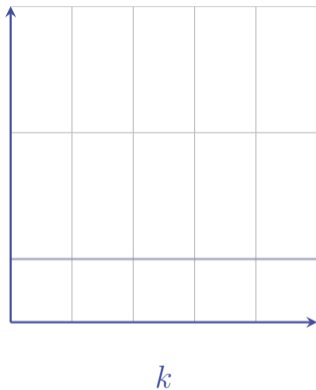
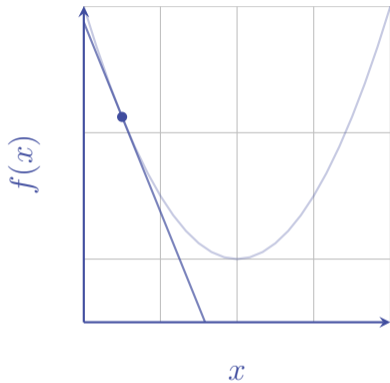


x

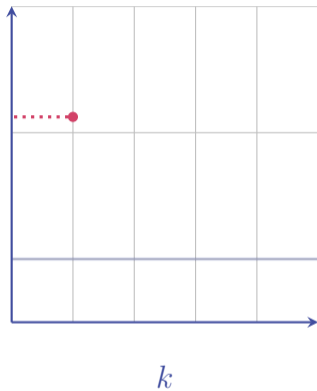
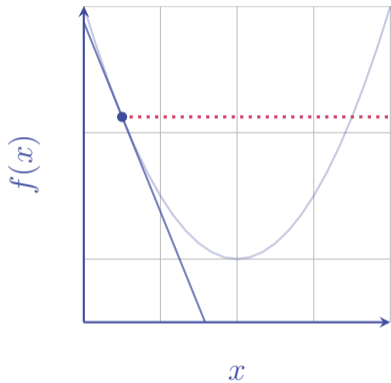


k

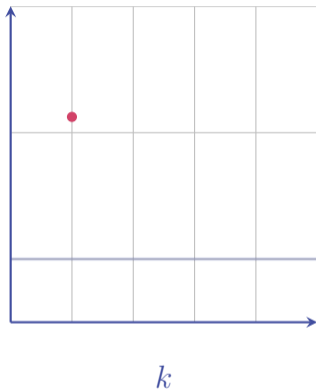
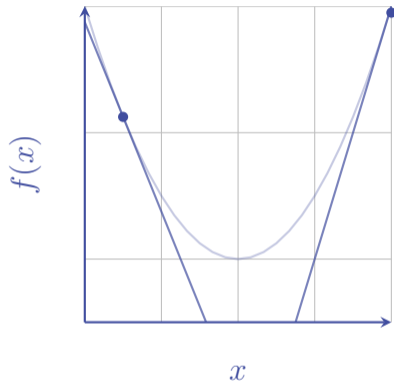
Kelley's Cutting Plane | A basic upper-bound



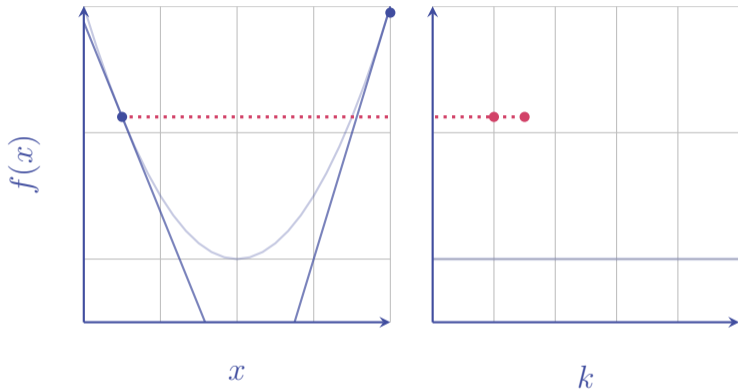
Kelley's Cutting Plane | A basic upper-bound



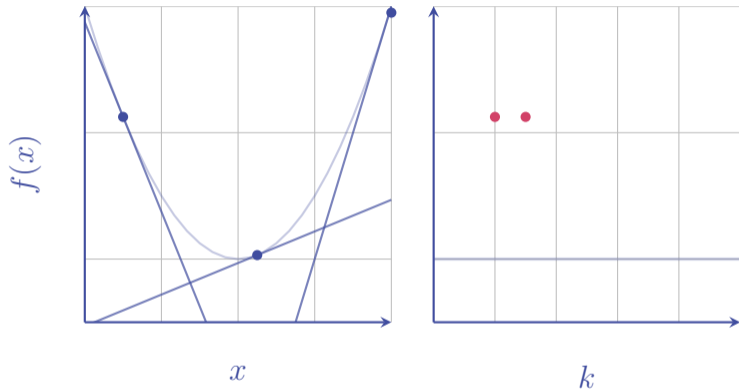
Kelley's Cutting Plane | A basic upper-bound



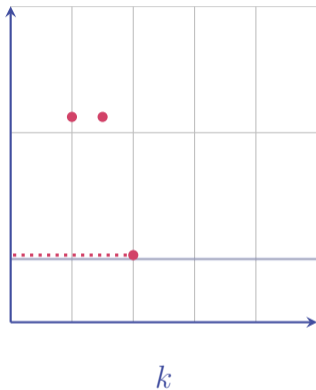
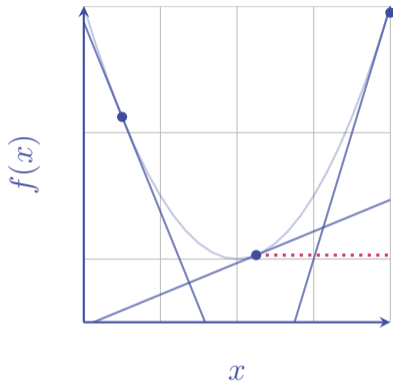
Kelley's Cutting Plane | A basic upper-bound



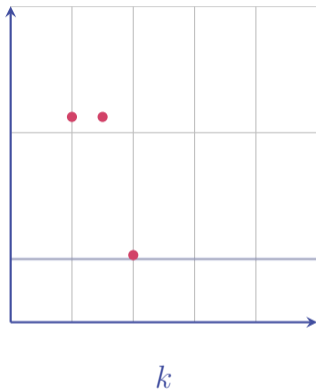
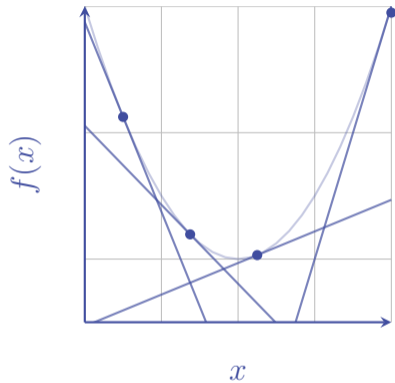
Kelley's Cutting Plane | A basic upper-bound



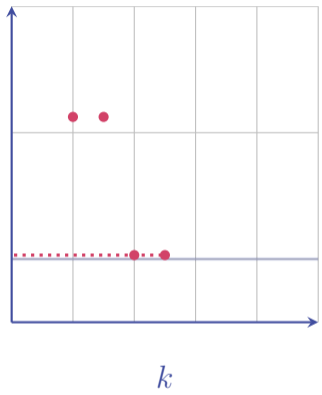
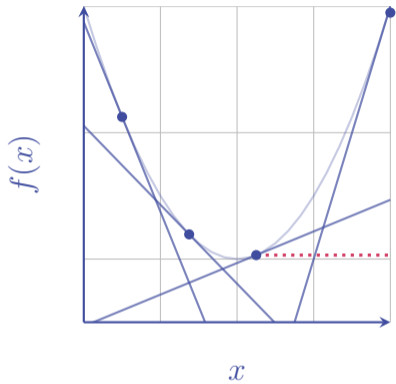
Kelley's Cutting Plane | A basic upper-bound



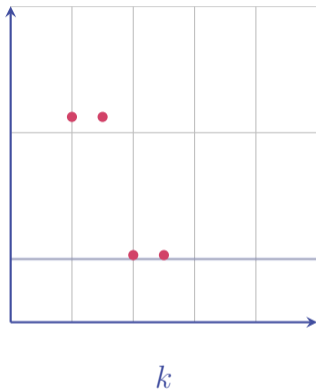
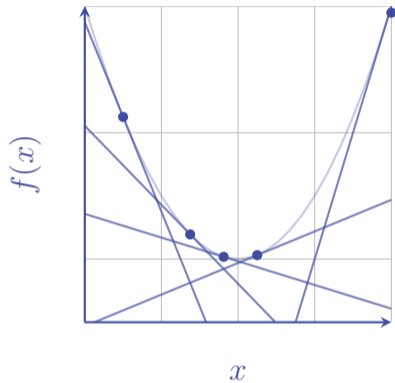
Kelley's Cutting Plane | A basic upper-bound



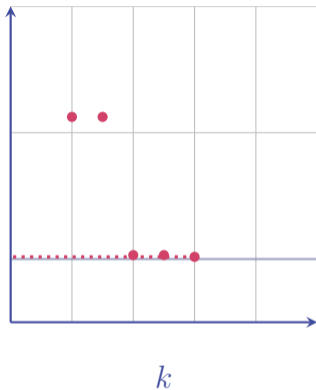
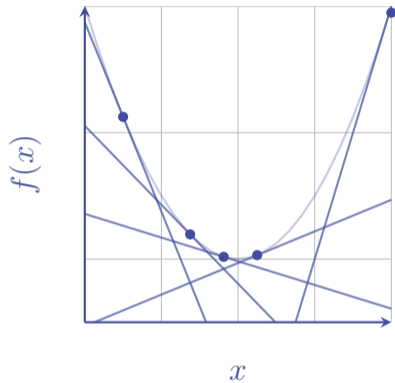
Kelley's Cutting Plane | A basic upper-bound



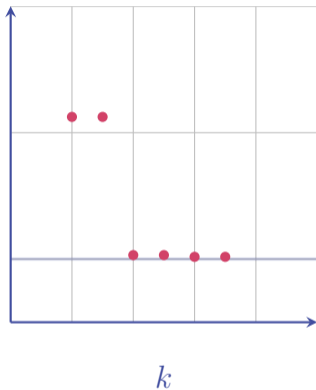
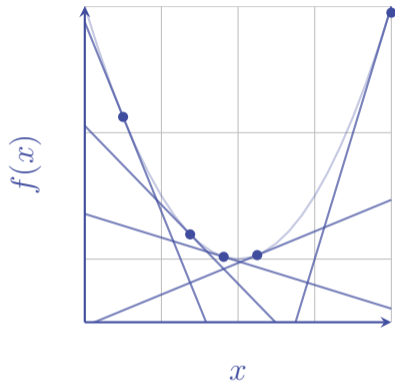
Kelley's Cutting Plane | A basic upper-bound



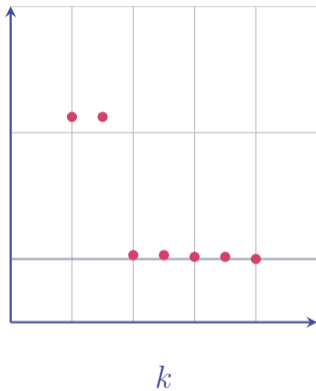
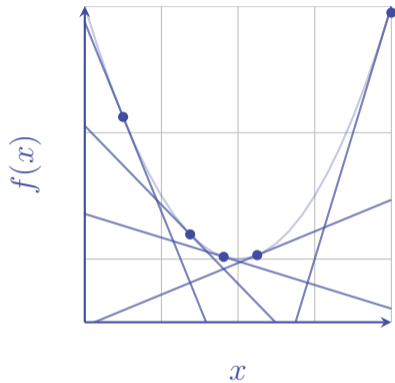
Kelley's Cutting Plane | A basic upper-bound



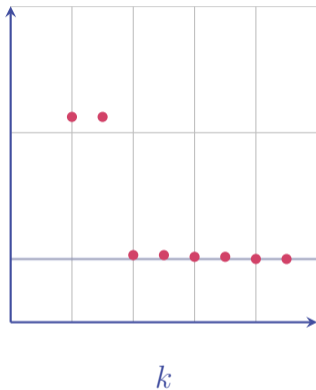
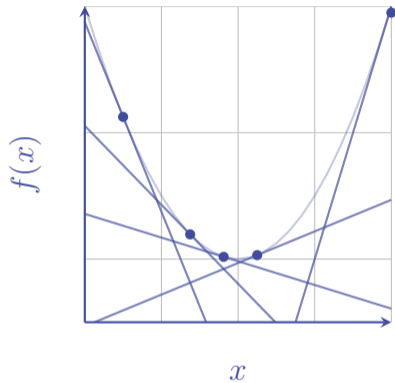
Kelley's Cutting Plane | A basic upper-bound



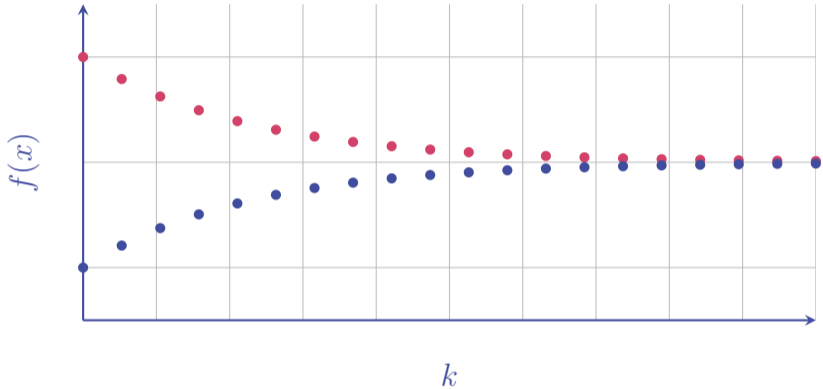
Kelley's Cutting Plane | A basic upper-bound



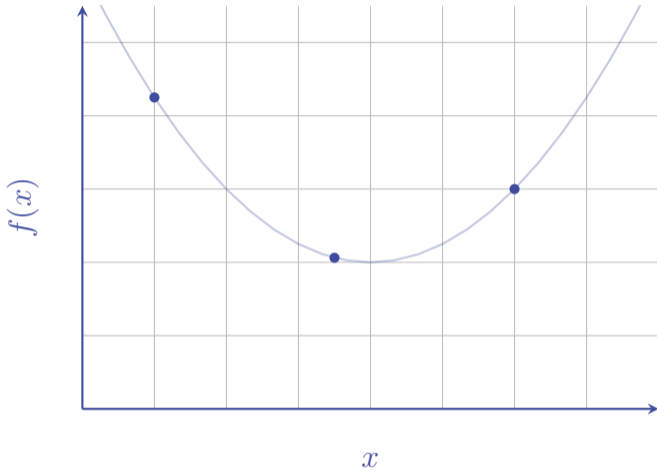
Kelley's Cutting Plane | A basic upper-bound



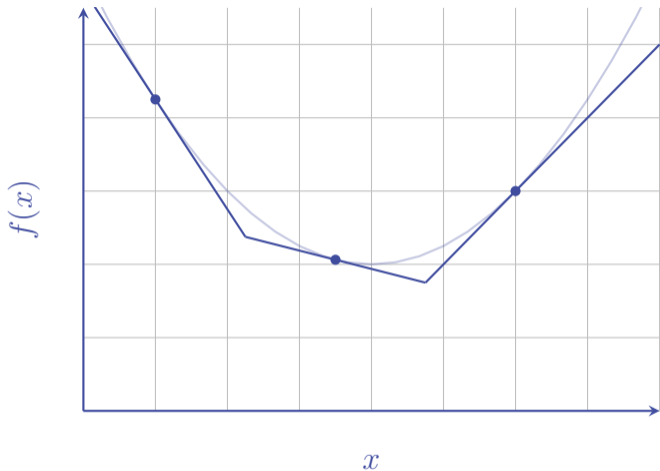
Kelley's Cutting Plane | A basic upper-bound



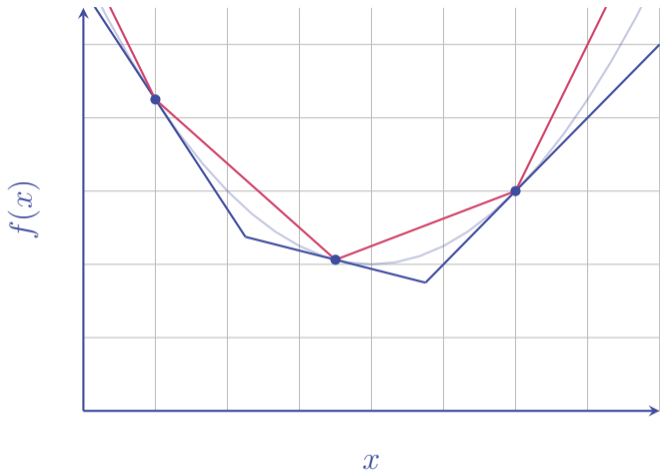
Kelley's Cutting Plane | A basic upper-bound



The upper-bound function | Construction

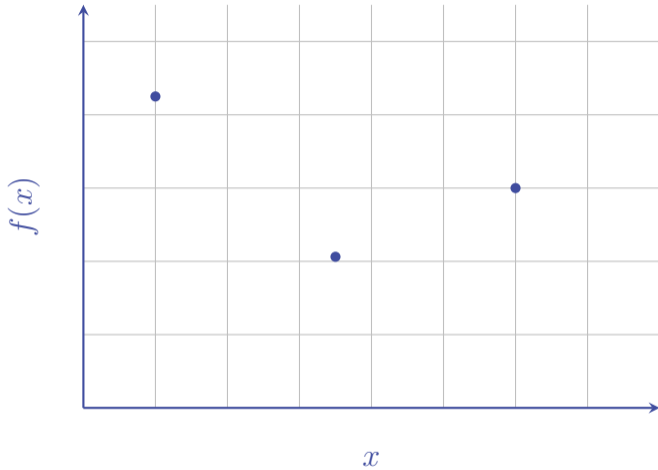


The upper-bound function | Construction

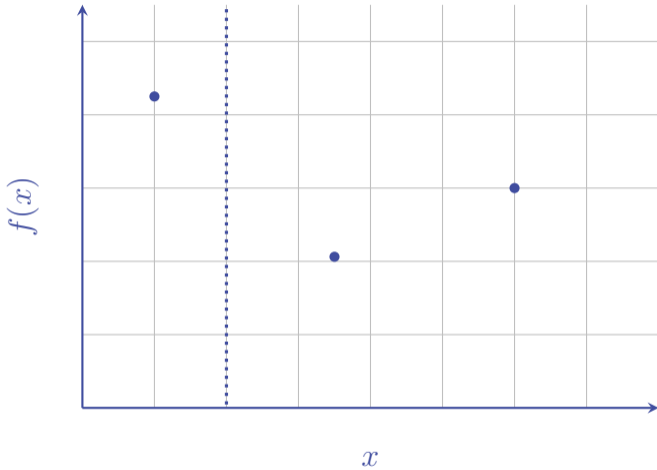


The upper-bound function | Construction

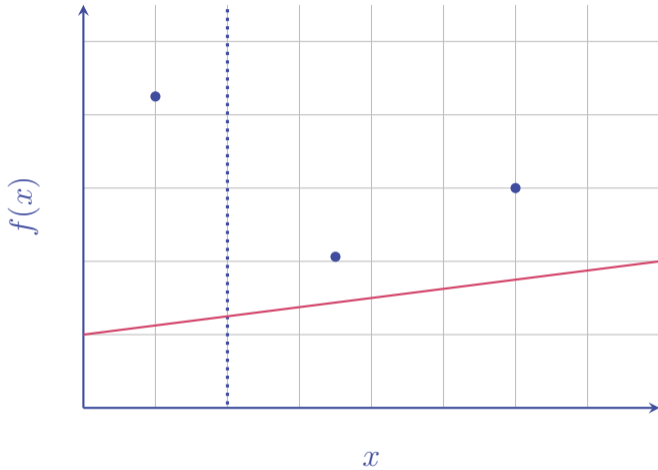
$\bar{f}(x)$ has a linear programming formulation.



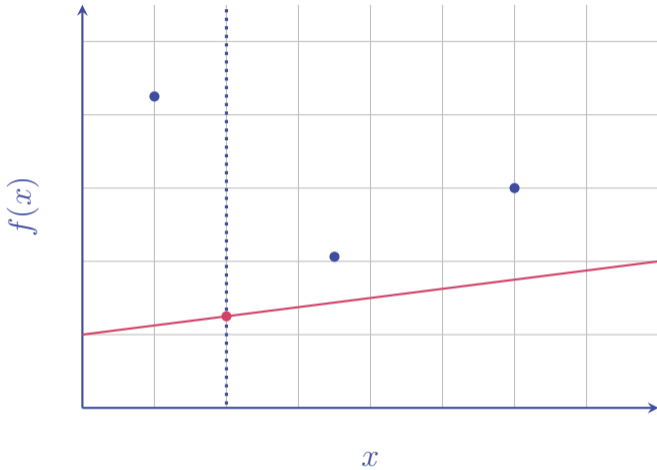
The upper-bound function | Hyperplanes



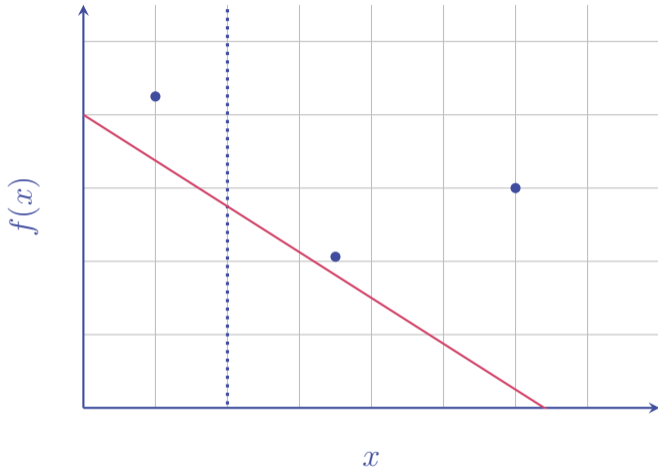
The upper-bound function | Hyperplanes



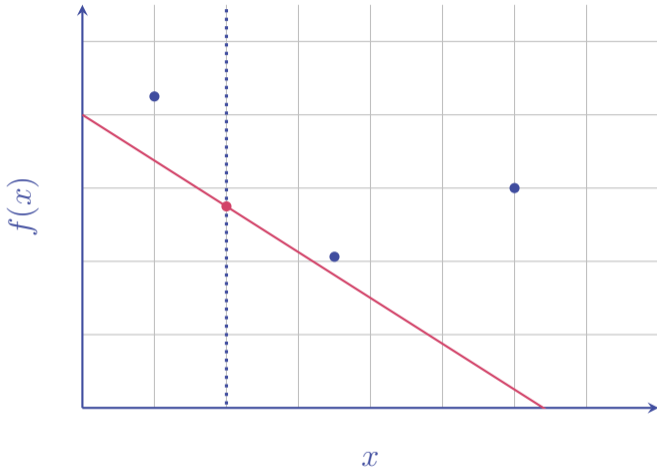
The upper-bound function | Hyperplanes



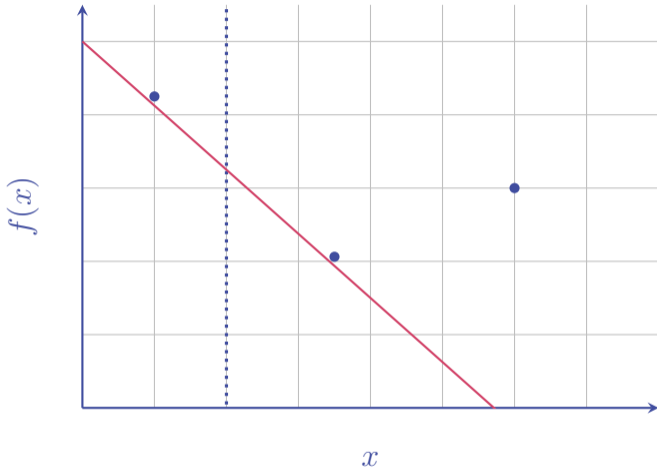
The upper-bound function | Hyperplanes



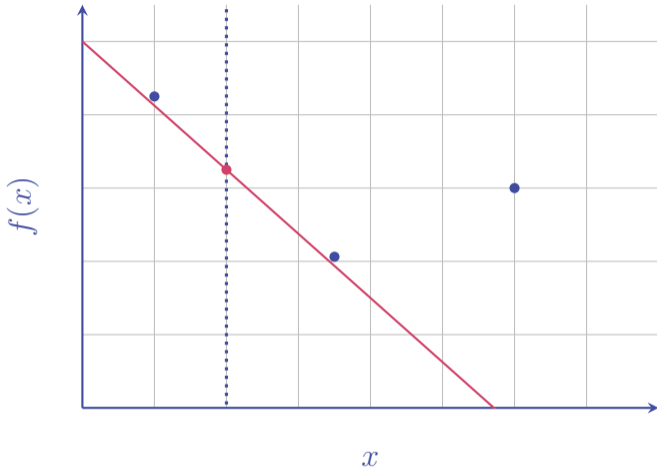
The upper-bound function | Hyperplanes



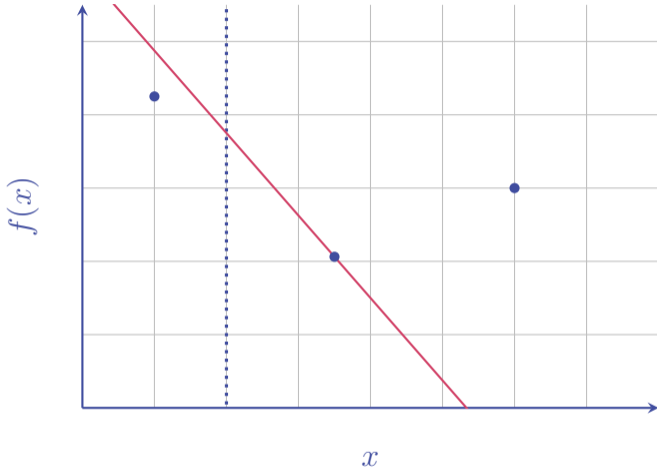
The upper-bound function | Hyperplanes



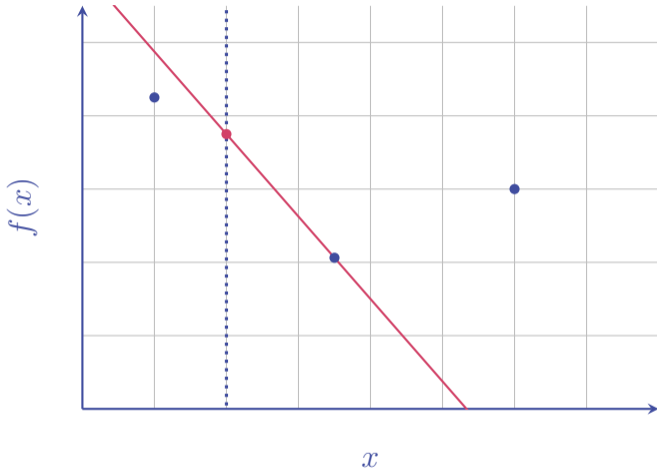
The upper-bound function | Hyperplanes



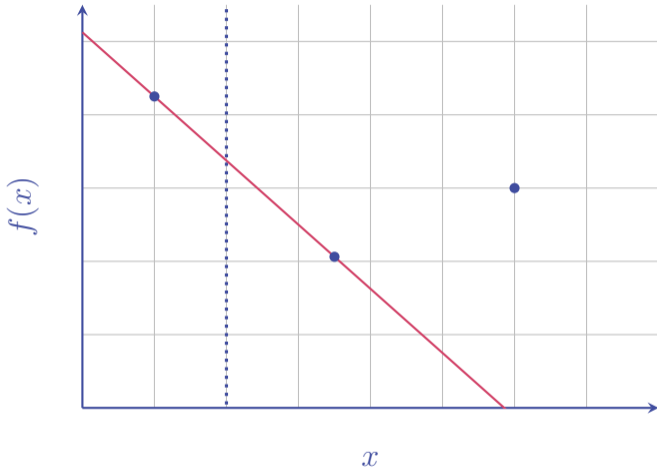
The upper-bound function | Hyperplanes



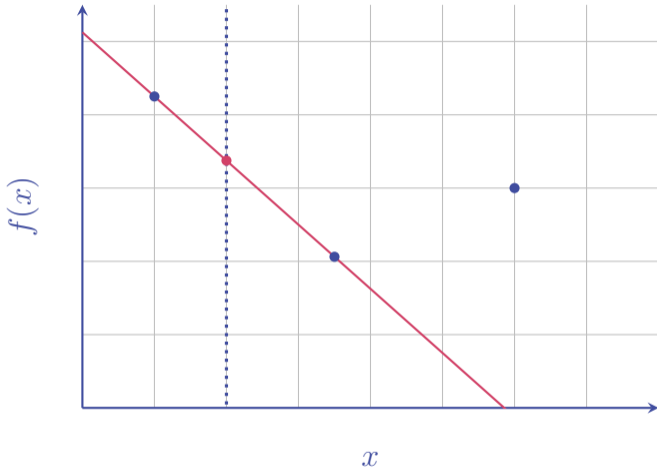
The upper-bound function | Hyperplanes



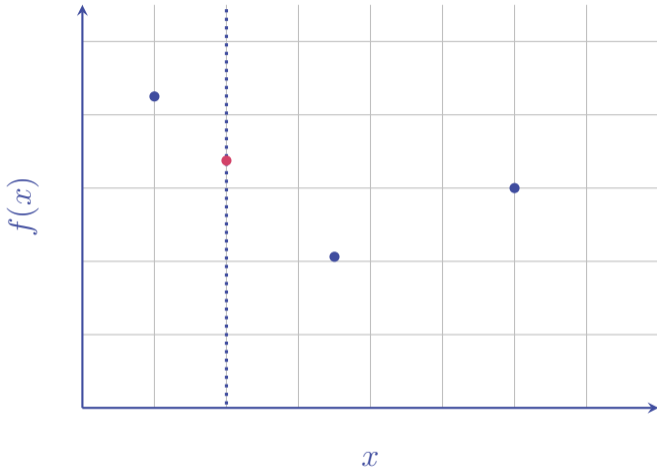
The upper-bound function | Hyperplanes



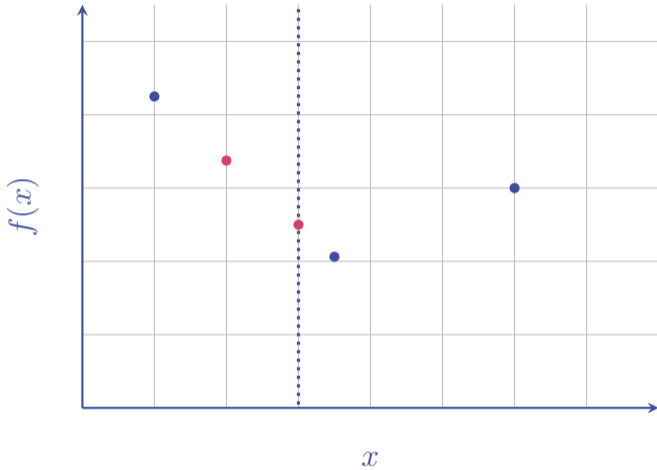
The upper-bound function | Hyperplanes



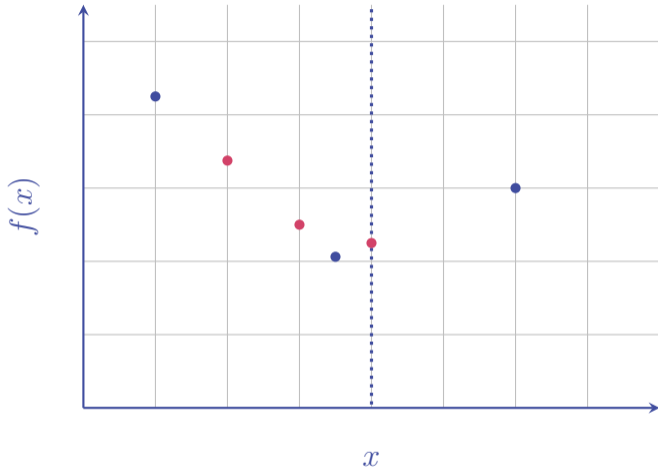
The upper-bound function | Hyperplanes



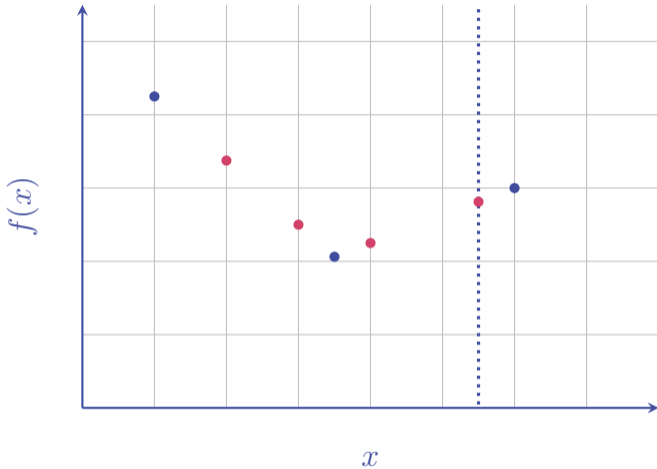
The upper-bound function | Hyperplanes



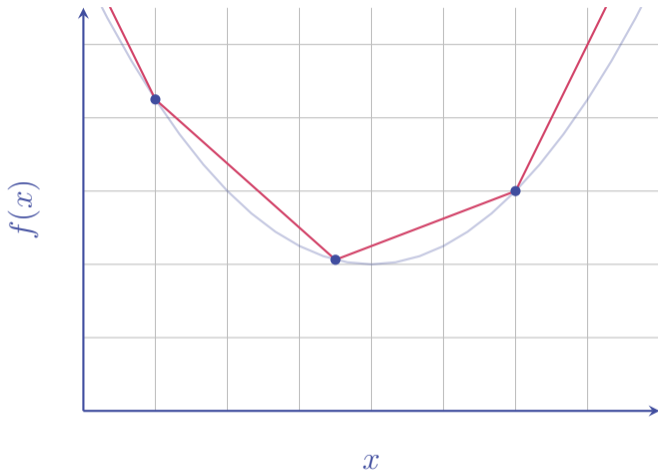
The upper-bound function | Hyperplanes



The upper-bound function | Hyperplanes

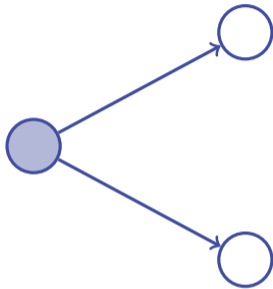


The upper-bound function | Hyperplanes

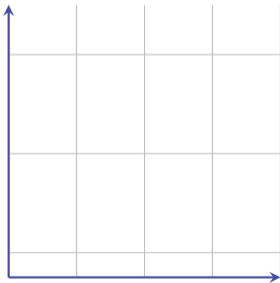
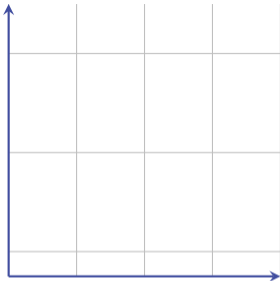
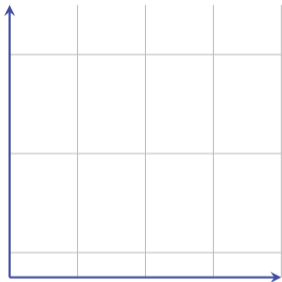


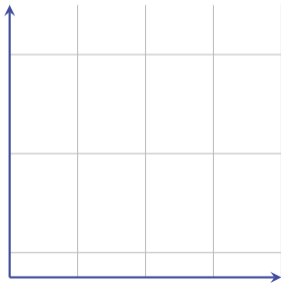
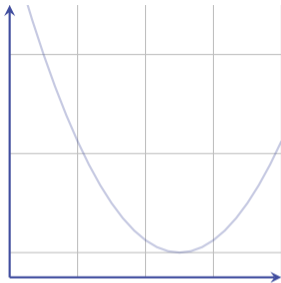
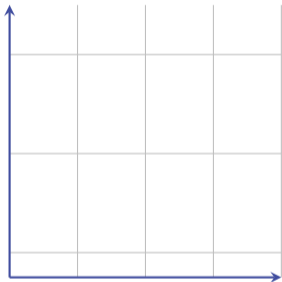
The upper-bound function | Hyperplanes

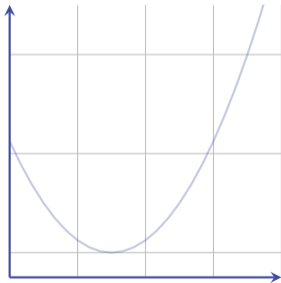
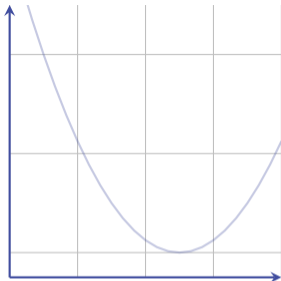
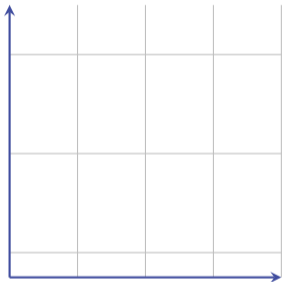
$$f^* = \min_{x \in \mathcal{X}} \sum_{\omega} p_{\omega} f_{\omega}(x)$$

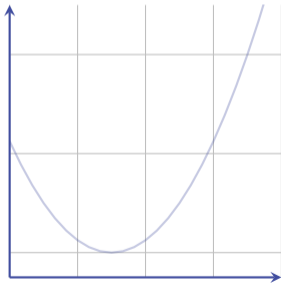
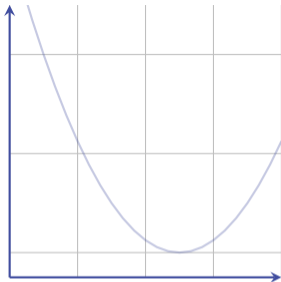
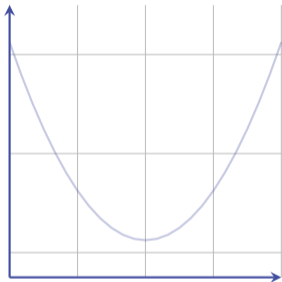


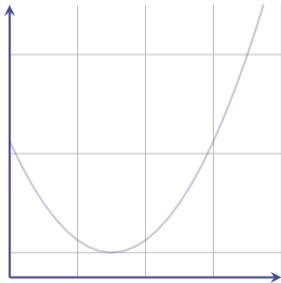
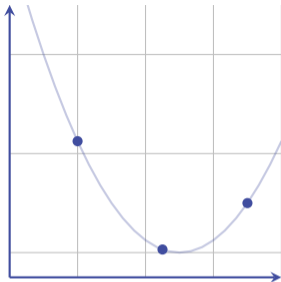
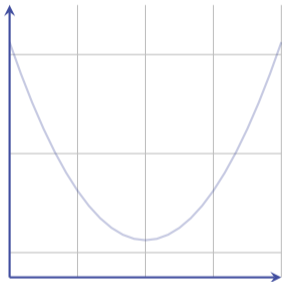
The algorithm | Two-stage problem

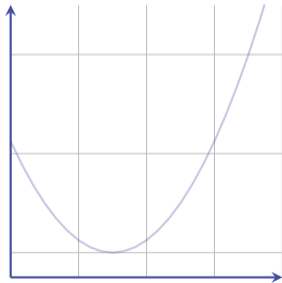
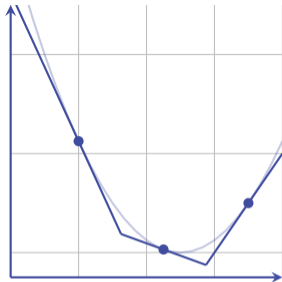
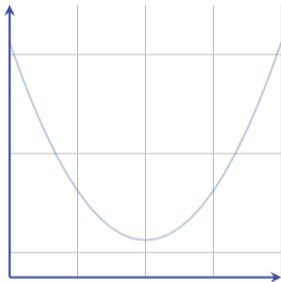


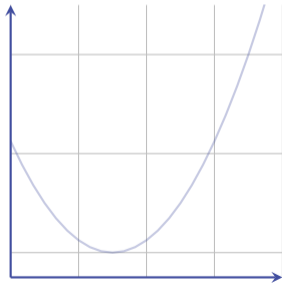
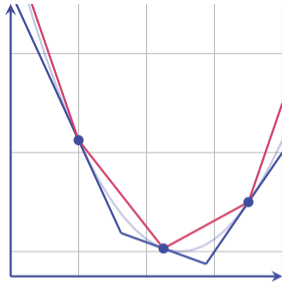
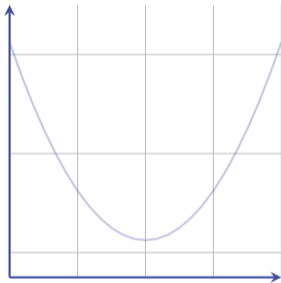


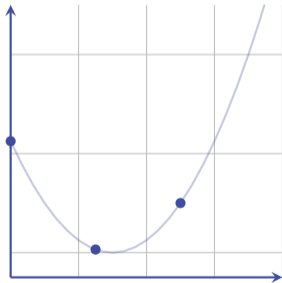
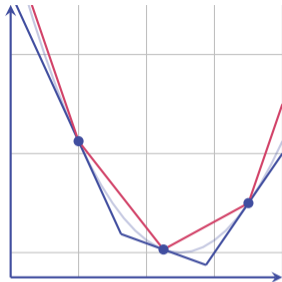
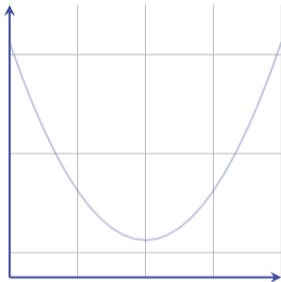


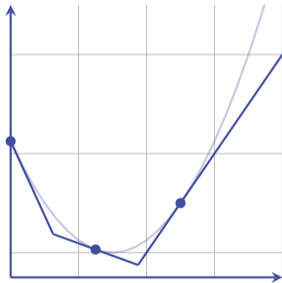
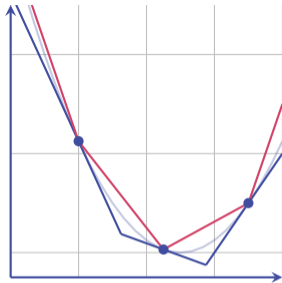
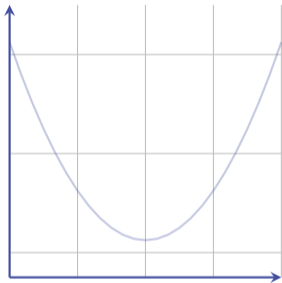


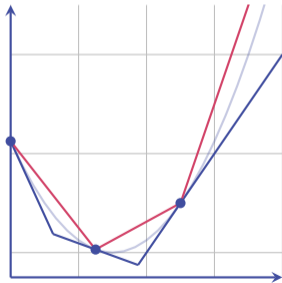
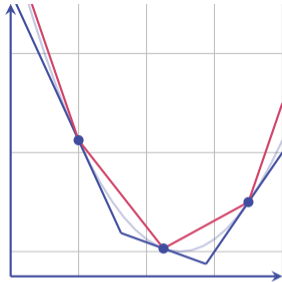
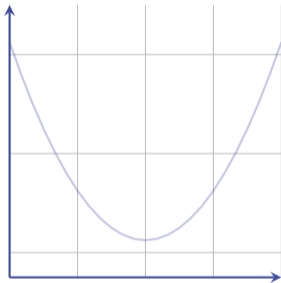


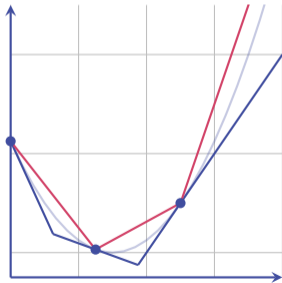
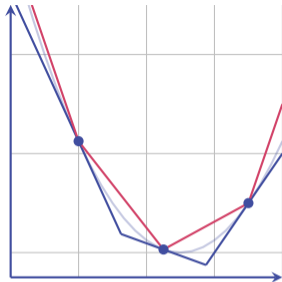
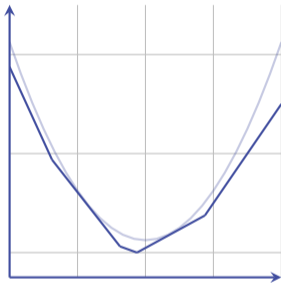


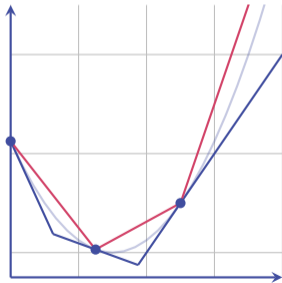
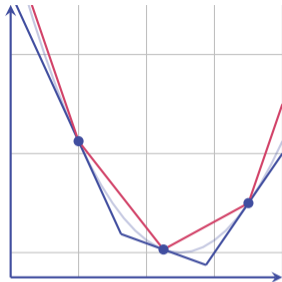
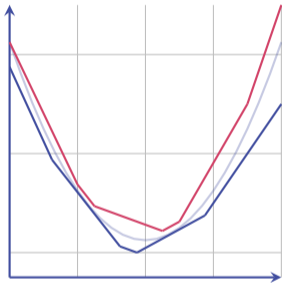


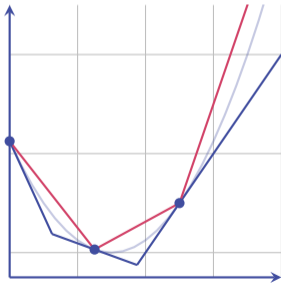
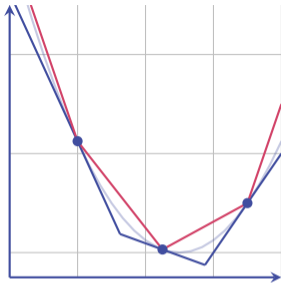
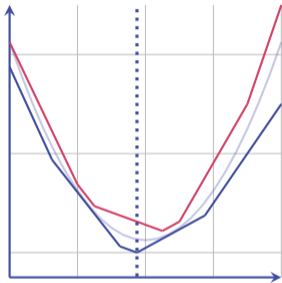


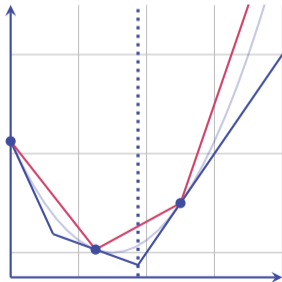
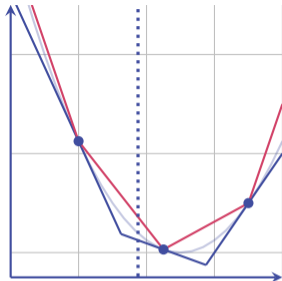
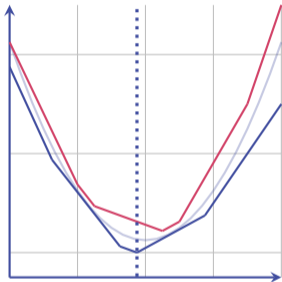


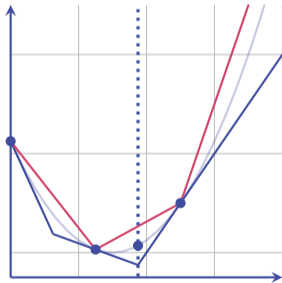
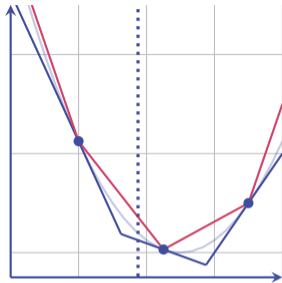
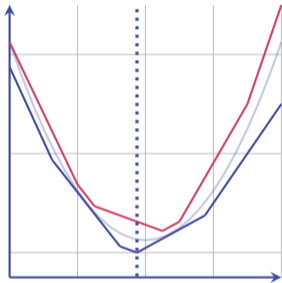


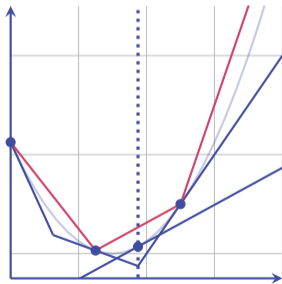
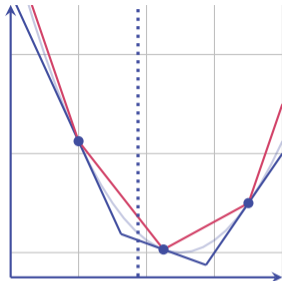
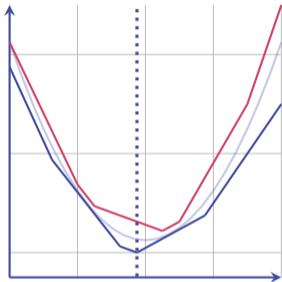


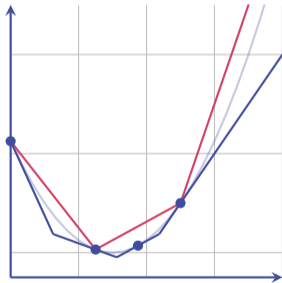
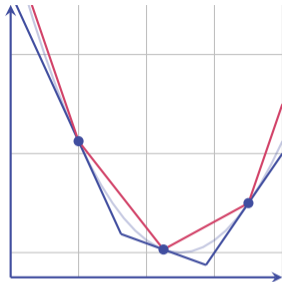
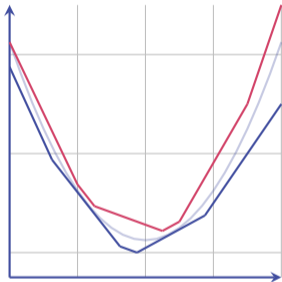


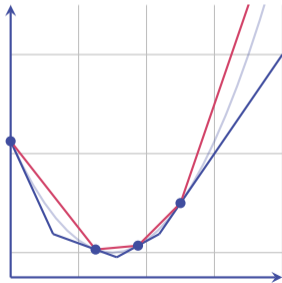
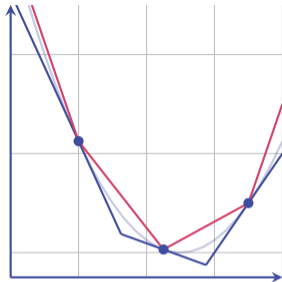
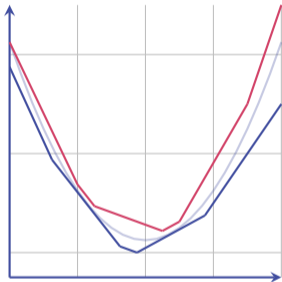


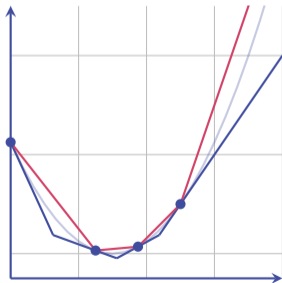
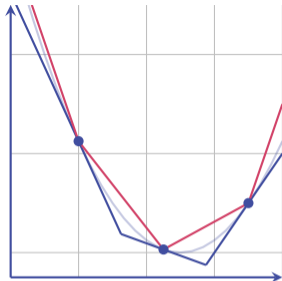
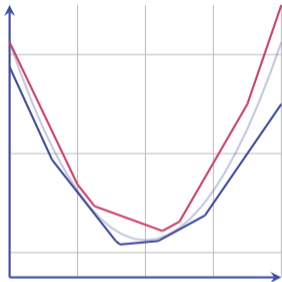


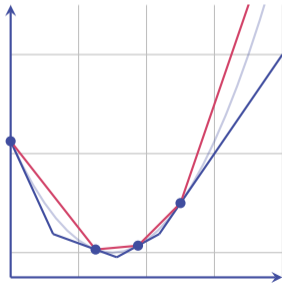
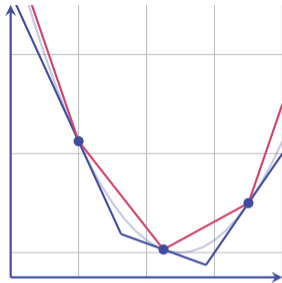
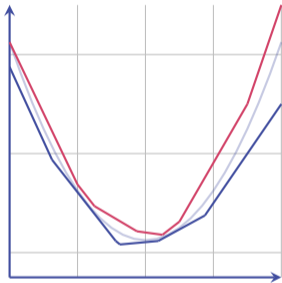


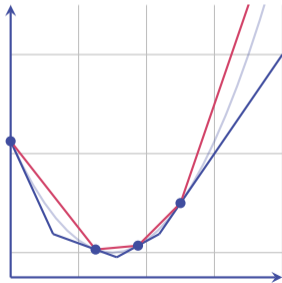
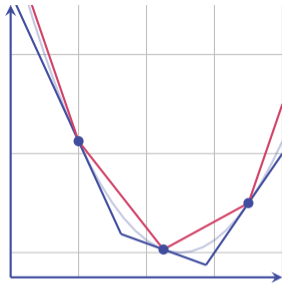
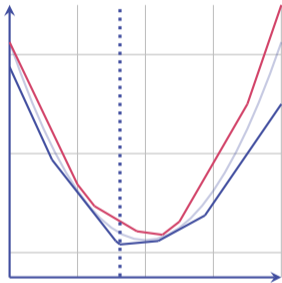


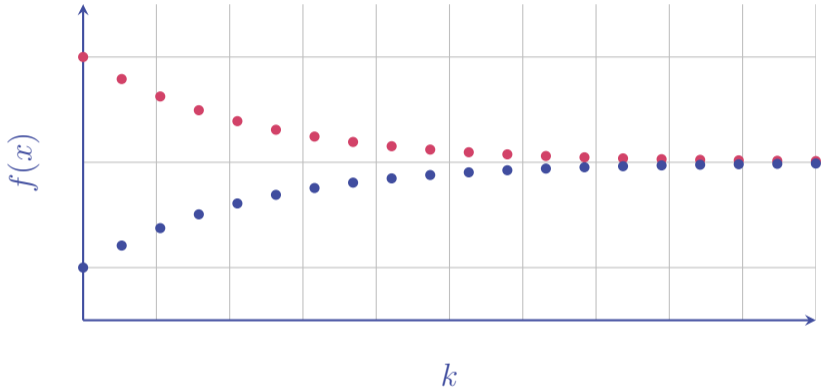




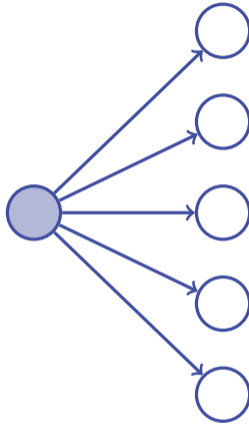




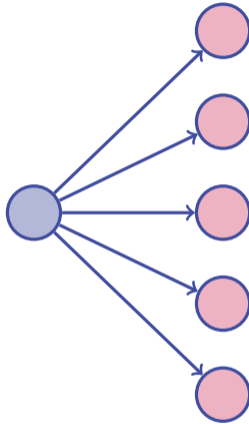




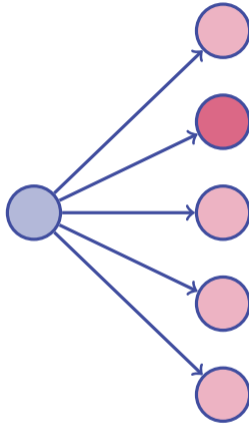
The algorithm | Two-stage problem



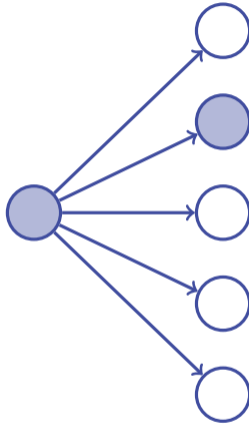
The algorithm | Two-stage problem



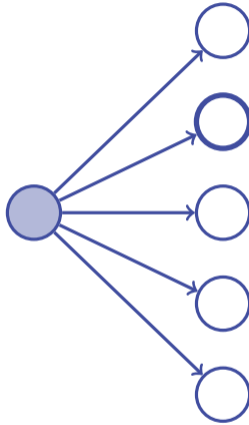
The algorithm | Two-stage problem



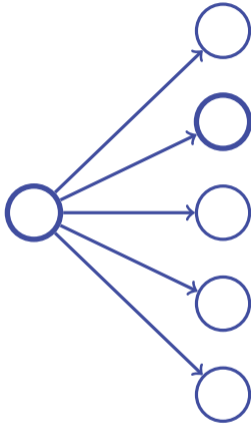
The algorithm | Two-stage problem



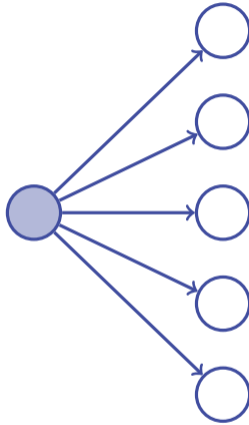
The algorithm | Two-stage problem



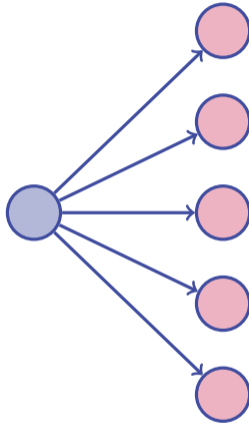
The algorithm | Two-stage problem



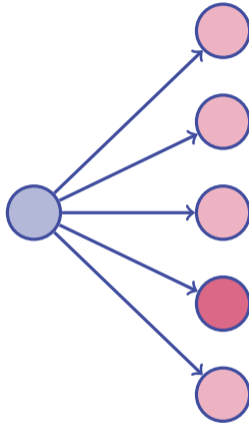
The algorithm | Two-stage problem



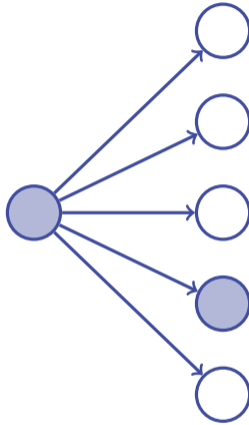
The algorithm | Two-stage problem



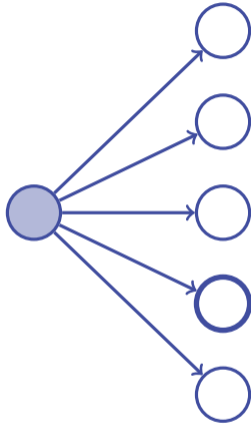
The algorithm | Two-stage problem



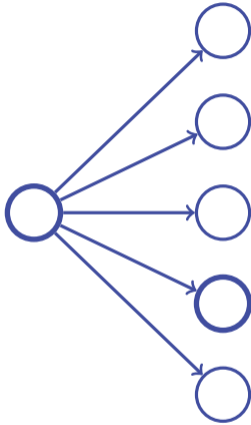
The algorithm | Two-stage problem



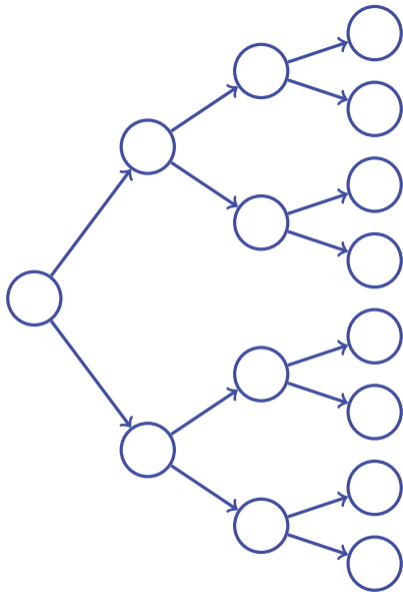
The algorithm | Two-stage problem



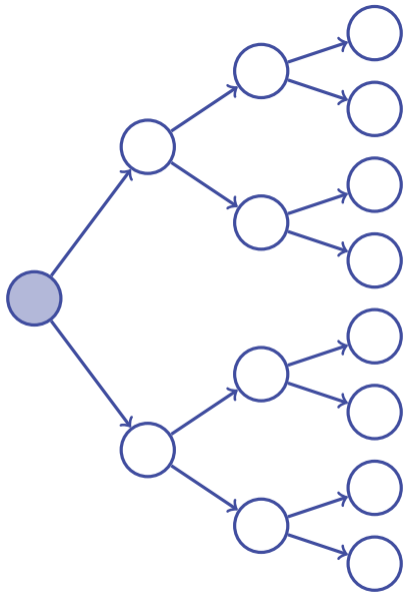
The algorithm | Two-stage problem



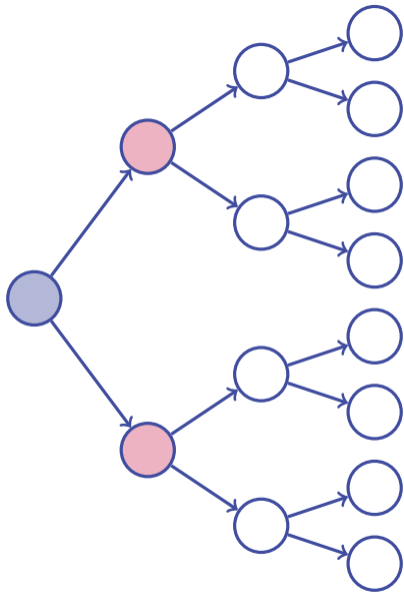
The algorithm | Two-stage problem



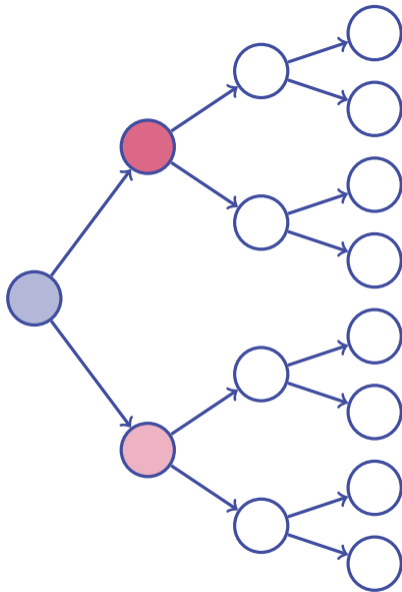
The algorithm | The multistage problem



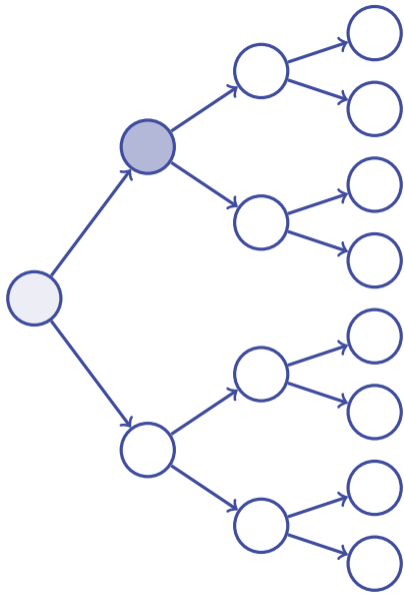
The algorithm | The multistage problem



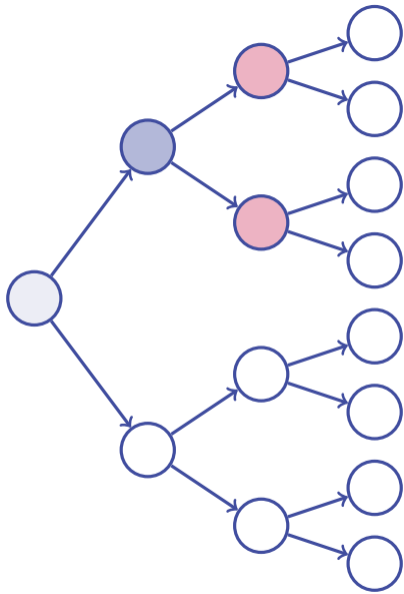
The algorithm | The multistage problem



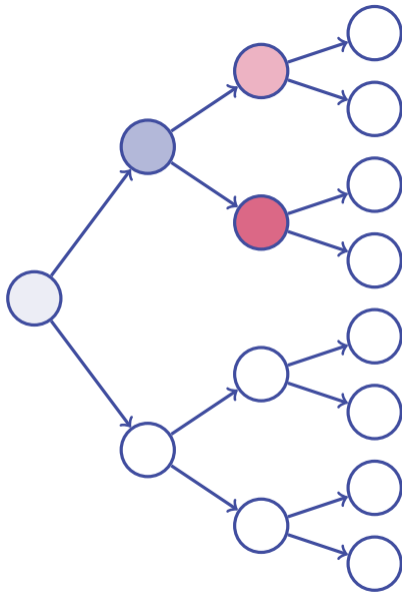
The algorithm | The multistage problem



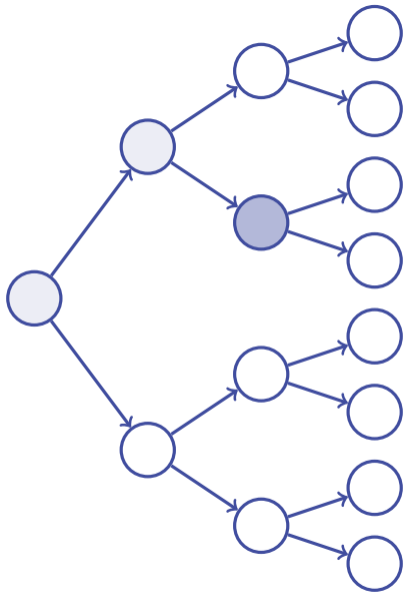
The algorithm | The multistage problem



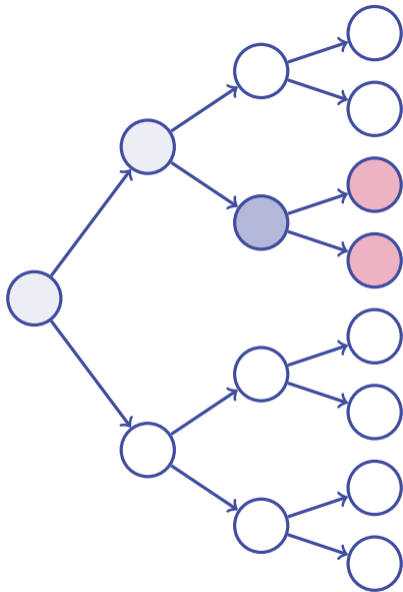
The algorithm | The multistage problem



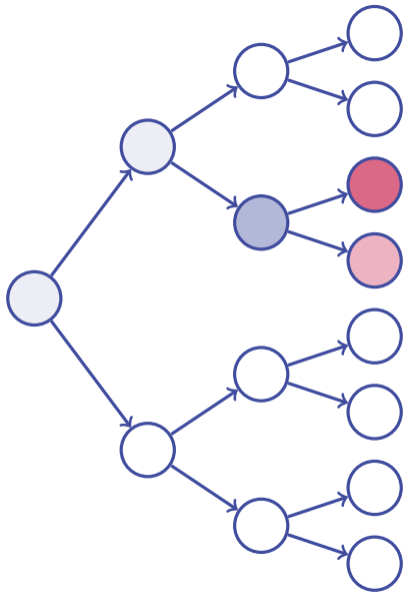
The algorithm | The multistage problem



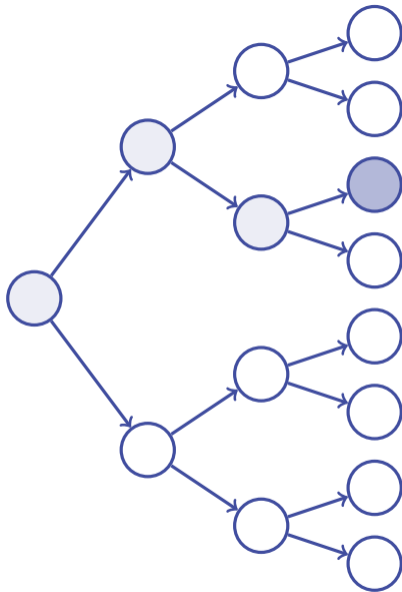
The algorithm | The multistage problem



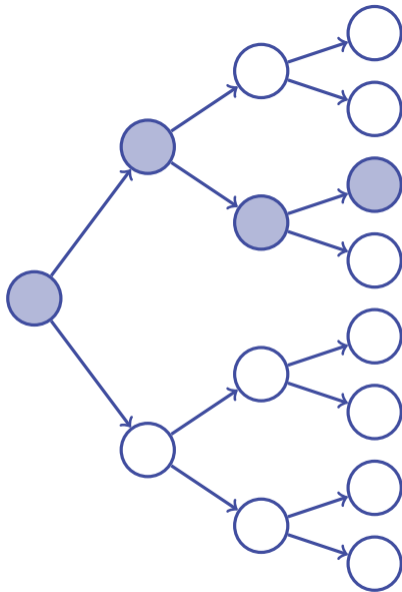
The algorithm | The multistage problem



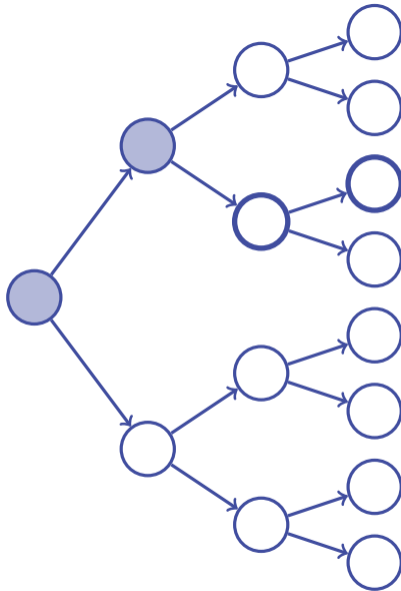
The algorithm | The multistage problem



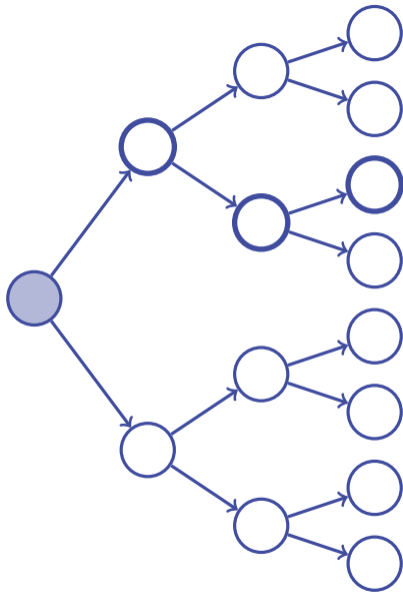
The algorithm | The multistage problem



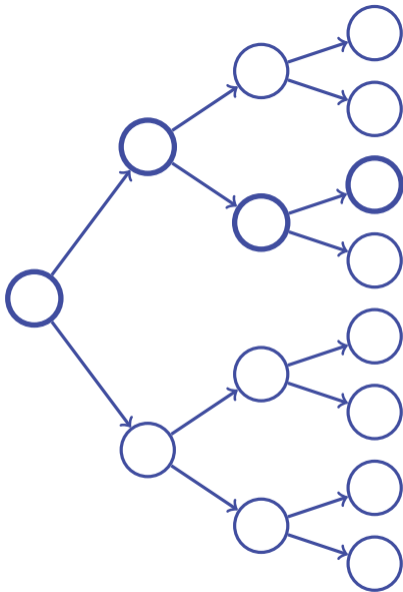
The algorithm | The multistage problem



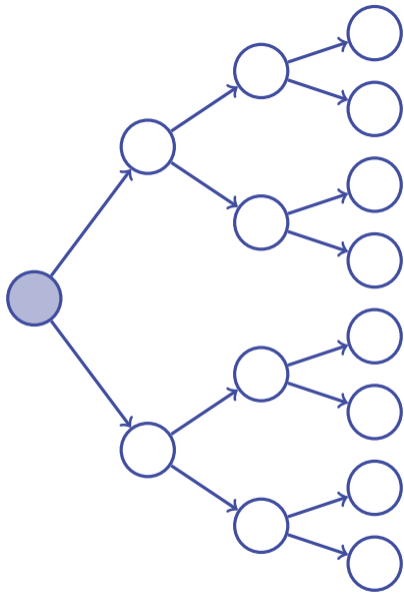
The algorithm | The multistage problem



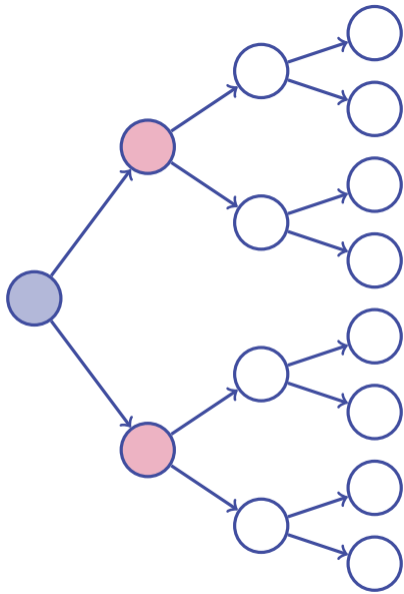
The algorithm | The multistage problem



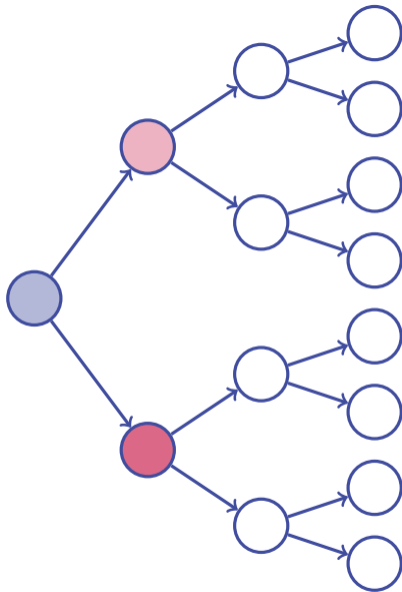
The algorithm | The multistage problem



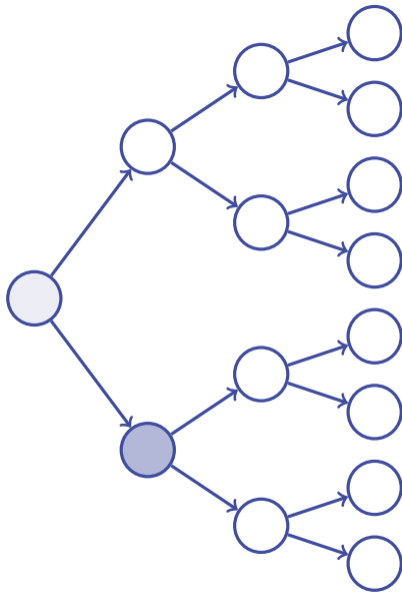
The algorithm | The multistage problem



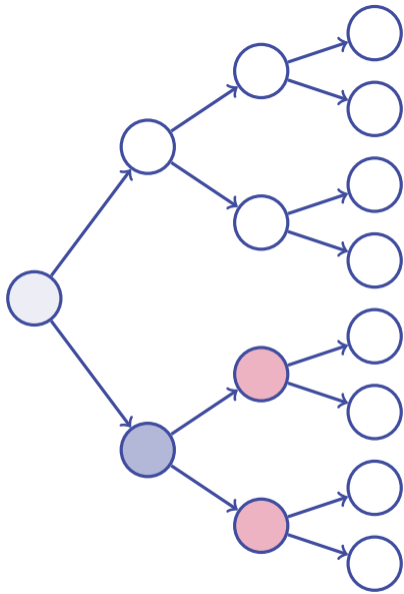
The algorithm | The multistage problem



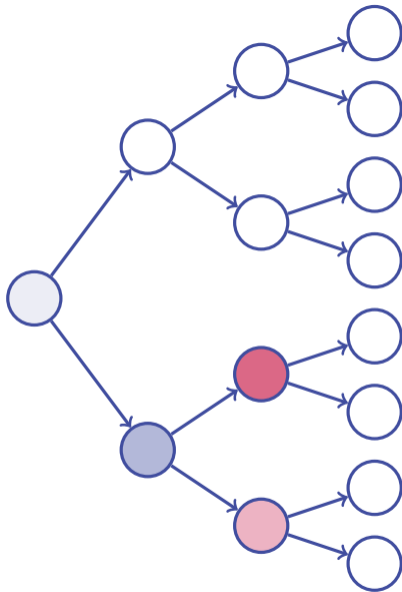
The algorithm | The multistage problem



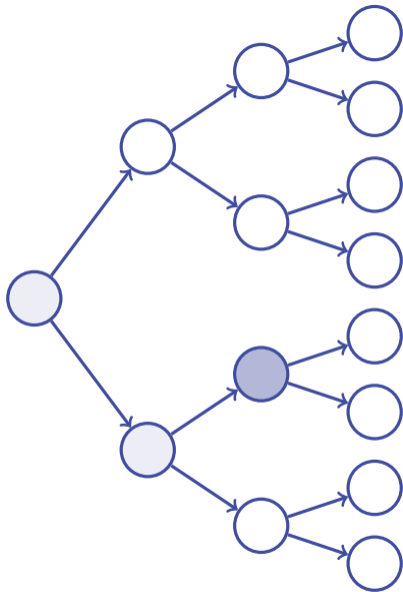
The algorithm | The multistage problem



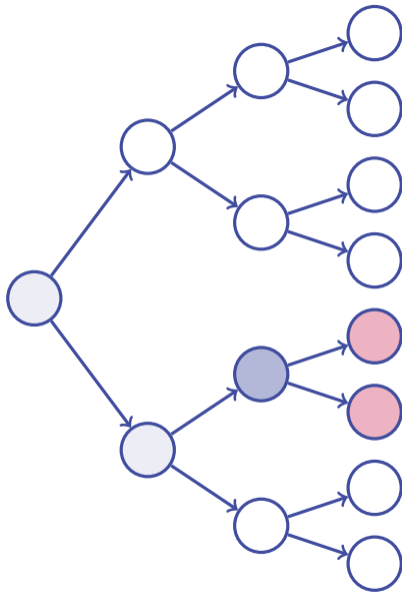
The algorithm | The multistage problem



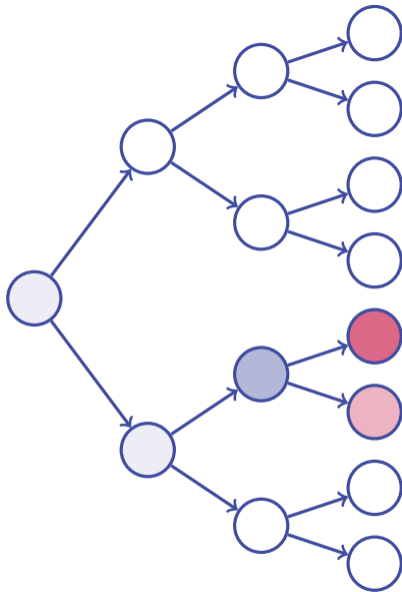
The algorithm | The multistage problem



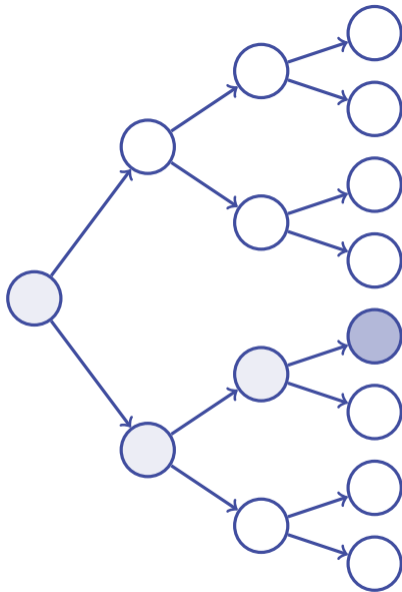
The algorithm | The multistage problem



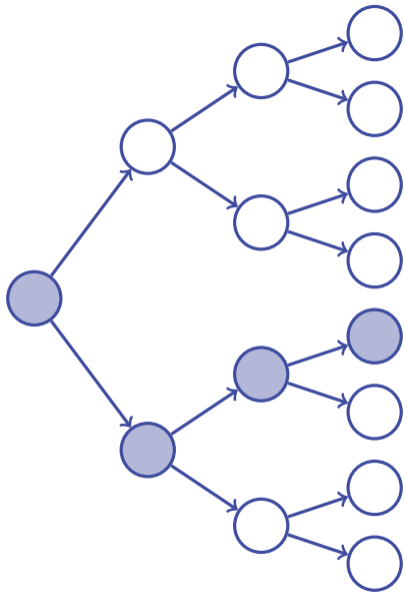
The algorithm | The multistage problem



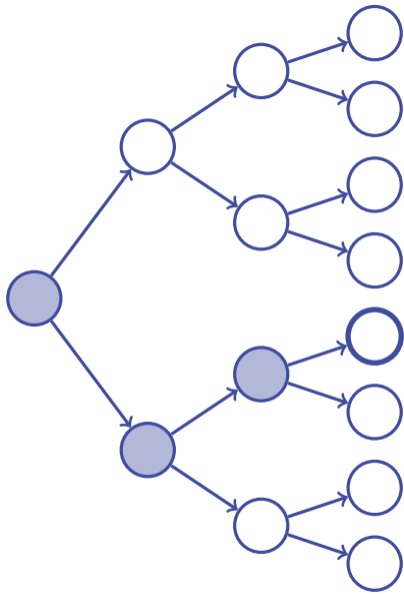
The algorithm | The multistage problem



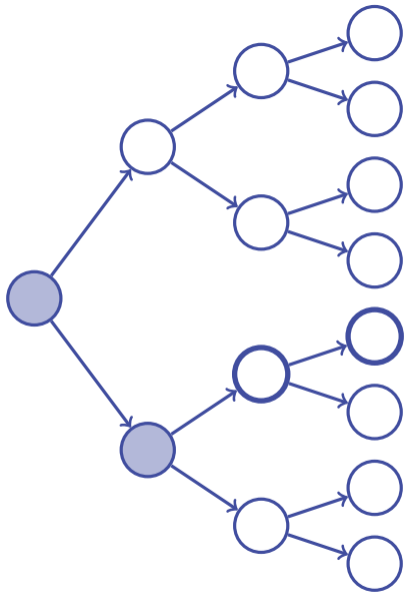
The algorithm | The multistage problem



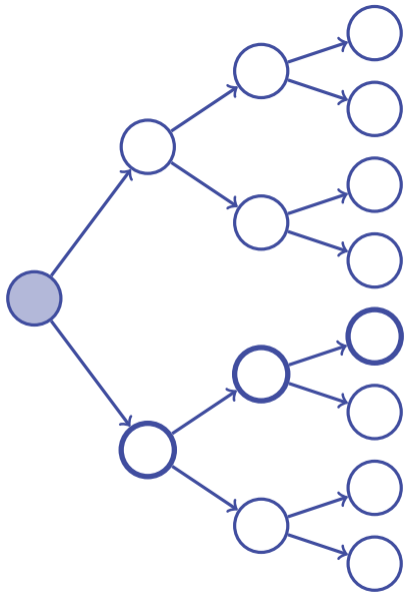
The algorithm | The multistage problem



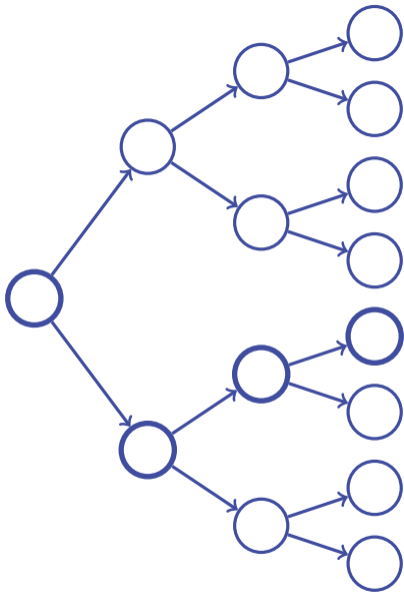
The algorithm | The multistage problem



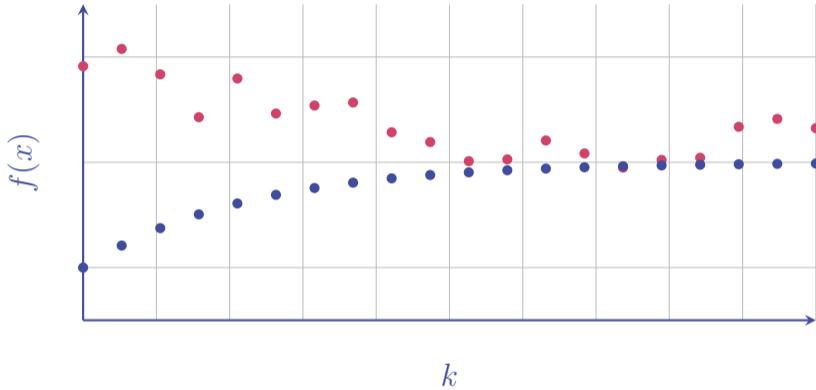
The algorithm | The multistage problem

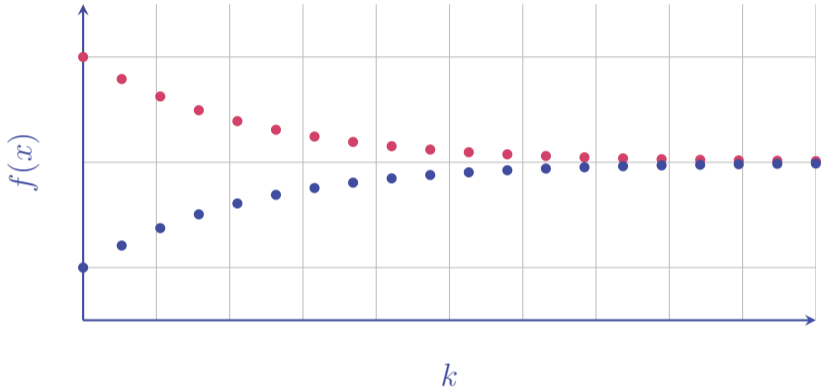


The algorithm | The multistage problem



The algorithm | The multistage problem





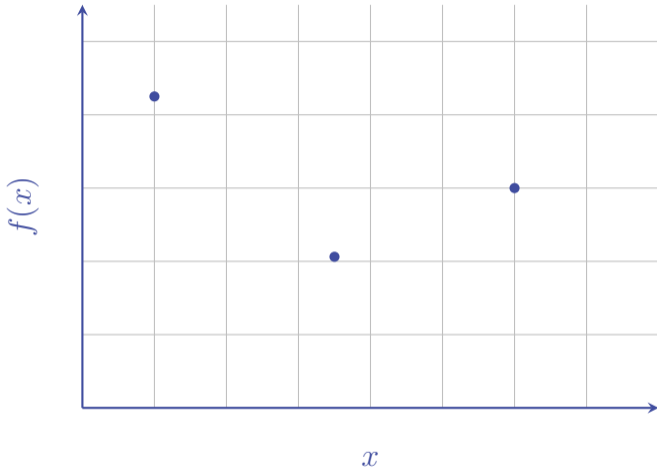
What does it all mean?

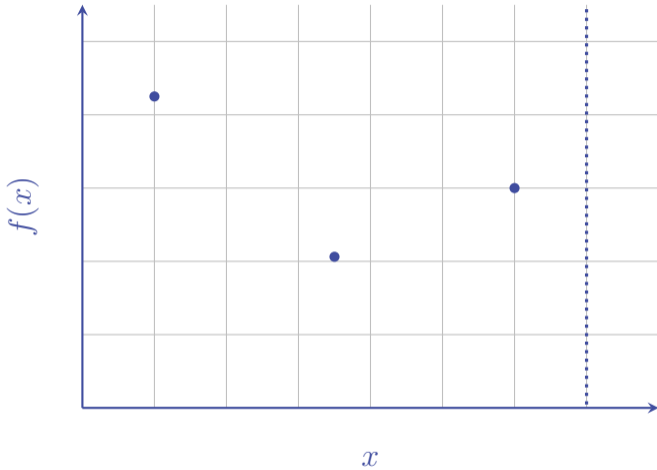
Kelley's Cutting Plane

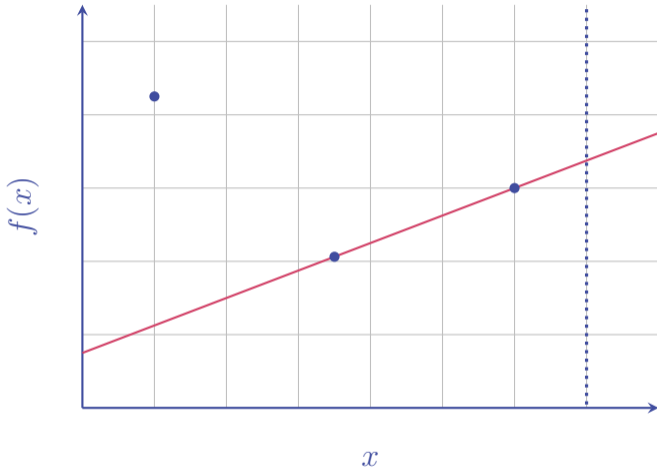
The upper-bound function

The algorithm

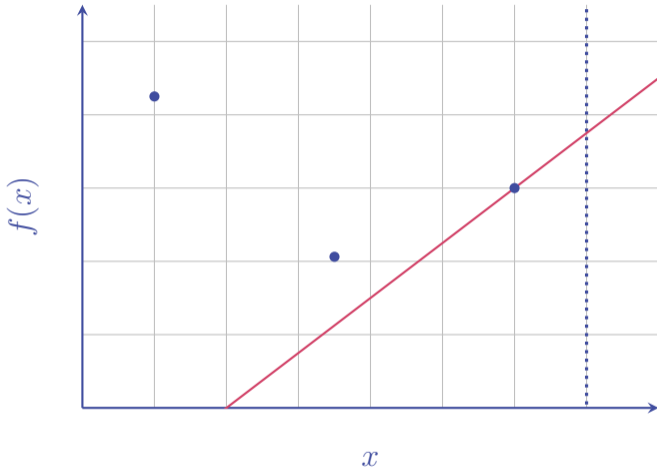
Conclusions



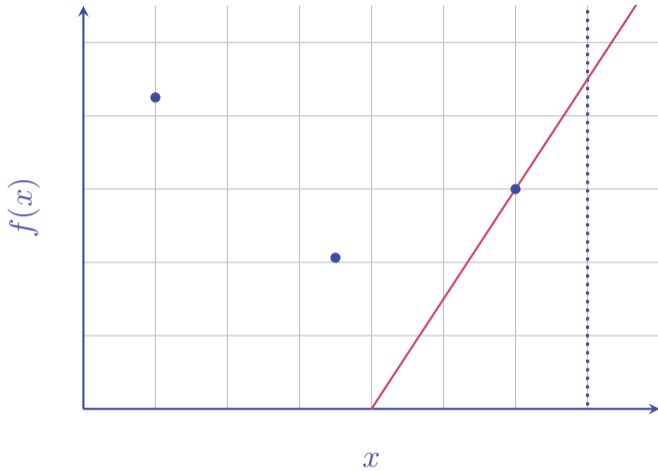


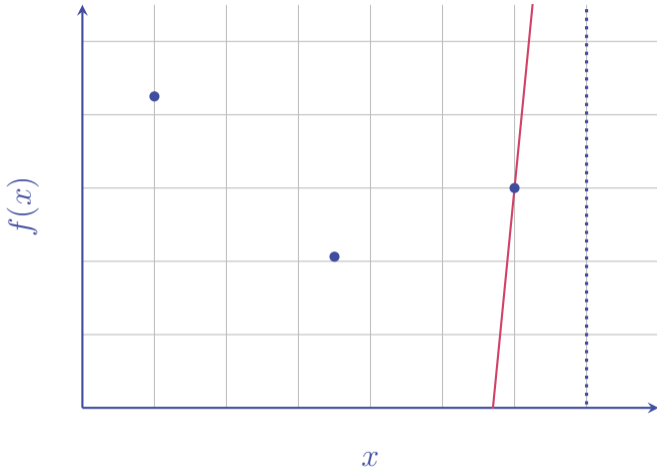


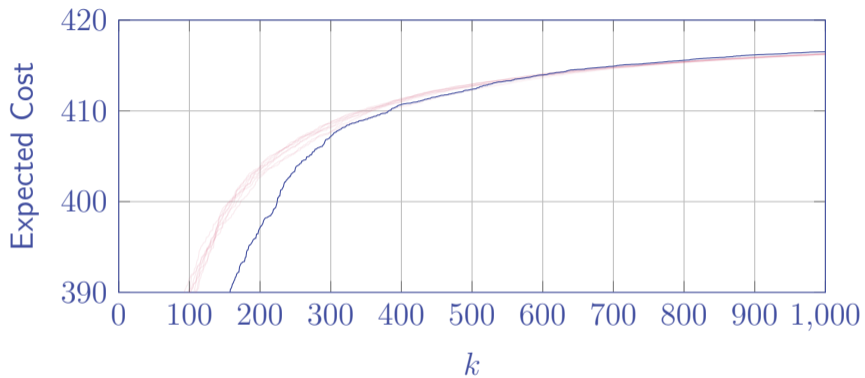
Extras | The upper-bound function



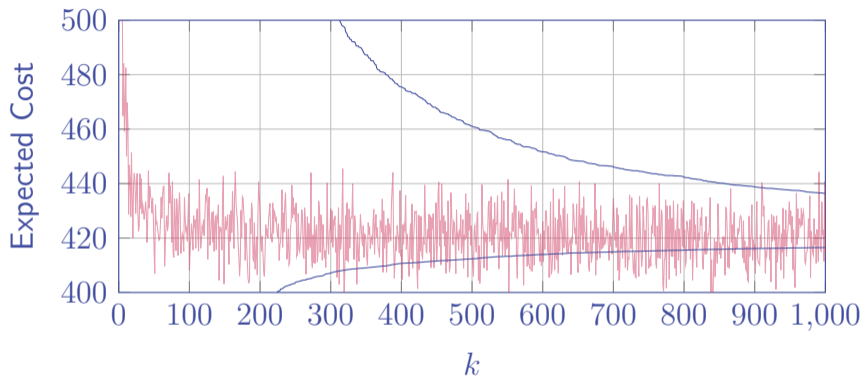
Extras | The upper-bound function







Extras | A big problem



- [1] J.E. Kelley. The cutting-plane method. *Journal of the Society for Industrial and Applied Mathematics*, 8(4):703–712, 1960.
- [2] P. Girardeau, V. Leclere, and A. B. Philpott. On the Convergence of Decomposition Methods for Multistage Stochastic Convex Programs. *Mathematics of Operations Research*, 40(1):130–145, 2014.
- [3] R. Baucke, A. Downward, and G. Zakeri. A deterministic algorithm for solving multistage stochastic programming problems. www.optimization-online.org, 2017.