

Where Should We Put This?

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Objective in Words

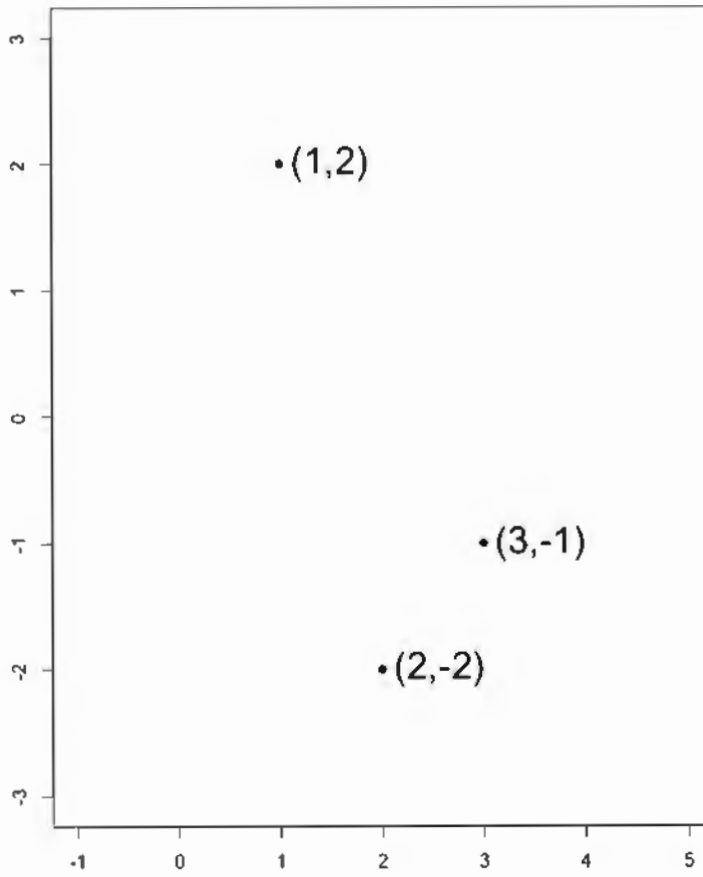
Decide **values for the decision variables** so that **an objective function** is maximized (minimized) subject to the following constraints:

- ...
- ...
- ...

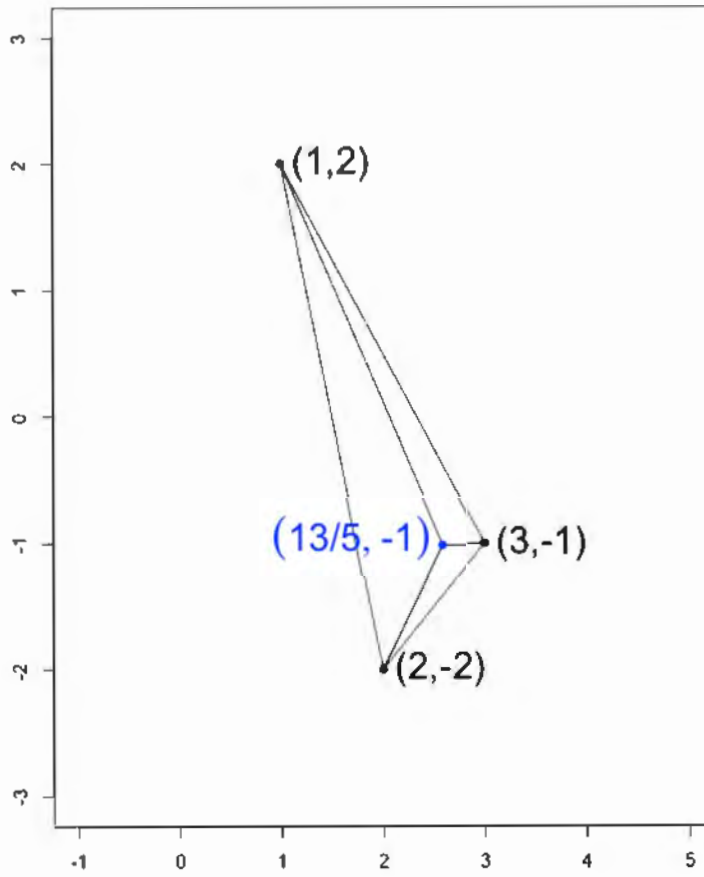
The Fermat-Torricelli Problem

Given three points in the plane, find the point having the minimal sum of distances to these three points.

Example 1



Example 1



Questions Optimizers Ask

- Does an optimal solution always exist?
- If so, is the solution unique?
- How can the optimal solution be obtained?
- What are characteristics of optimal solutions?
- How long does it take to obtain an optimal solution?
- How well can an optimal solution be approximated?

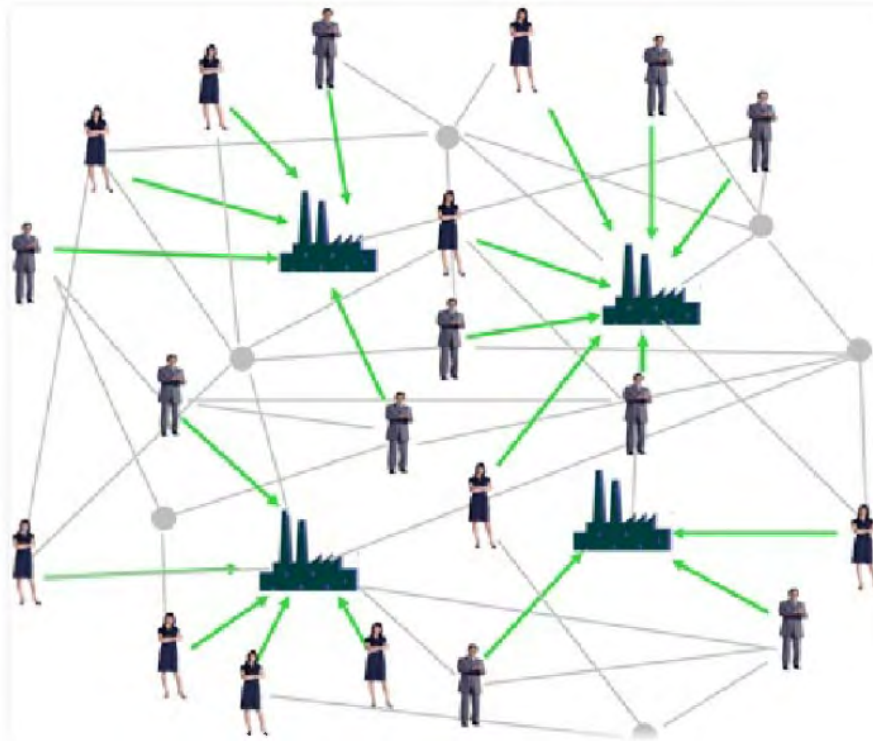
Aspects of the Fermat-Torricelli Solution

Theorem. Given three points in (\mathbb{R}^2) ,

- (Torricelli) if the angles of the triangle formed by the three points are less than 120 degrees, then the point minimizing the sum of Euclidean distances to the points is the *isogonal point* of the triangle.
- (Cavalieri) if one of the angles of the triangle formed by the three points is at least 120 degrees, then the points minimizing the sum of Euclidean distances to the points is the vertex of the triangle associated with the obtuse angle.

Generalizations have been studied, extending the problem to (n) points, (\mathbb{R}^m) , other distance metrics, and other objects (e.g., locate lines, planes, hyperplanes, subspaces, etc.). For more, see Bruno, G., Genovese, A., Improta, G. "A Historical Perspective on Location Problems" *BSHM Bulletin*. 29:83-97, 2014.

So What?



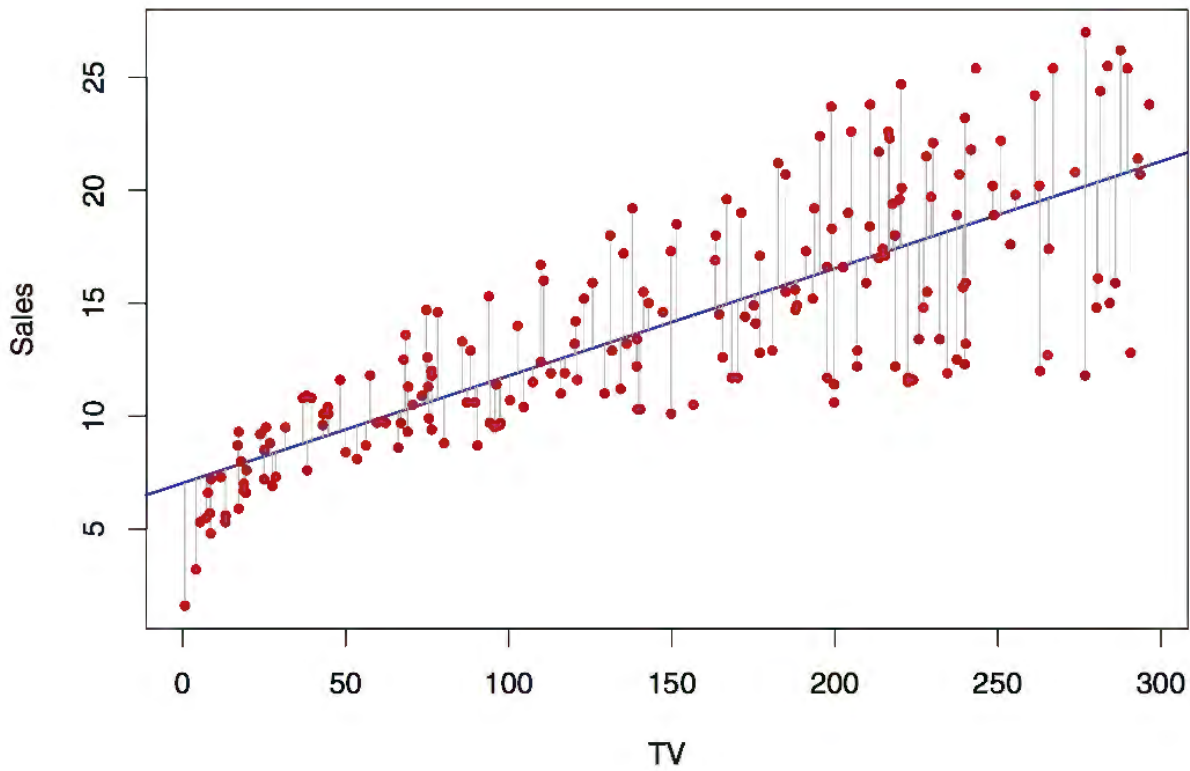
from Musial (2012)

What Else?



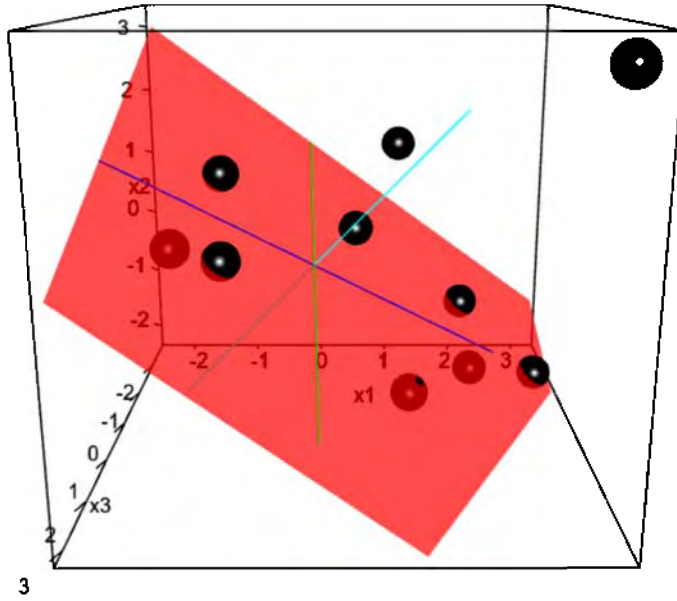
from itsmarta.com

Applications in Statistics

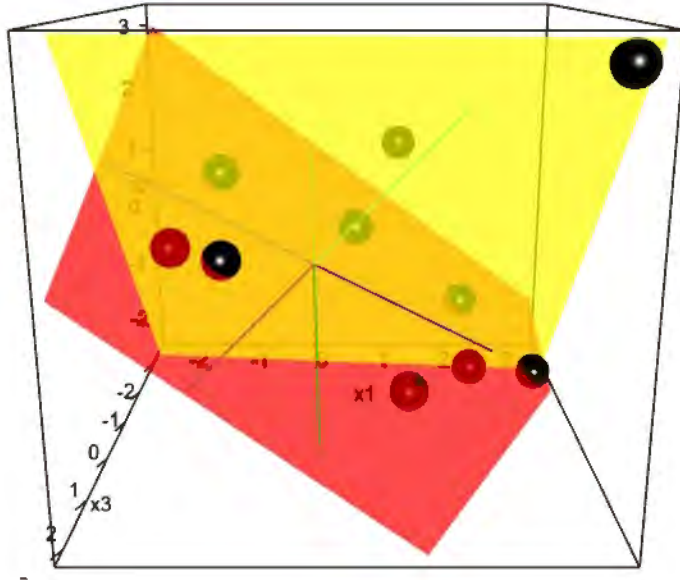


by Dawny33 on datascience.stackexchange.com

Principal Component Analysis



Principal Component Analysis



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- What are characteristics of optimal solutions?
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- How well can an optimal solution be approximated?

You and Your Research

Hamming, R. "You and Your Research," *New School Economic Review*.
3:5-26, 2008.

Do you want to do something significant with your life?



from wikipedia.org

Graduate School Options

- MBA
- JD
- MD
- Education
- MS/PhD in humanities
- **MS/PhD in science/engineering/mathematical sciences**

Q. What is the only valid reason to pursue a Ph.D. in science or engineering, or the mathematical sciences?

A. Love of the subject.



All You Need Is Love by Cmlszr on DeviantArt

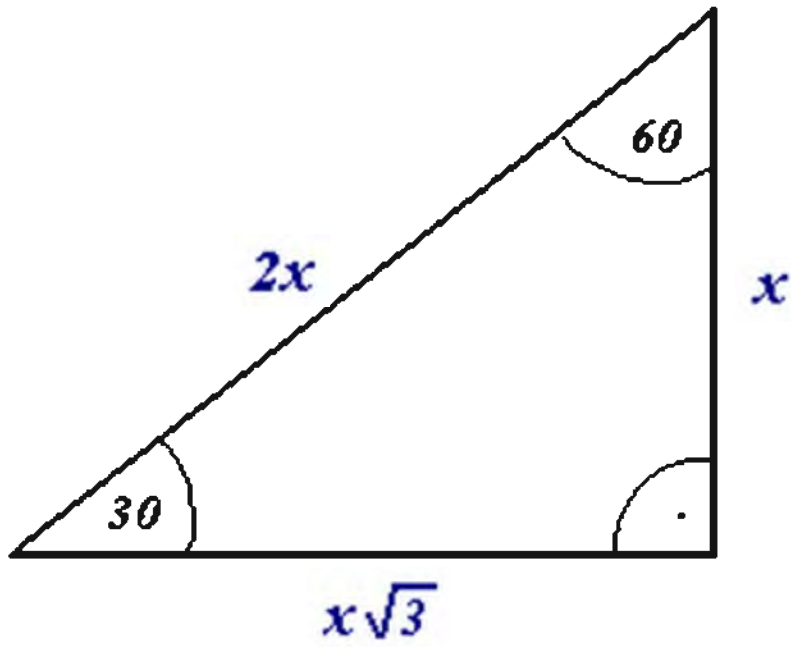
Opportunities/Perks of Graduate School in Science and Engineering

- An M.S. is not a prerequisite for applying to a Ph.D. program.
- Teaching and research assistantships available.
- NSF/DOE/DOD assistantships available.
- U.S. students are in demand.

Applying and Getting In

- Your transcript
- GRE scores
- TOEFL
- Personal statement
- Letters of recommendation

The GRE



from wikipedia.org

Doing Well Once You're In

- Love
- Courage
- Patience
- Drive
- Ability to recover from failure
- Luck?

Doing Well Once You're In

- Mathematics
- Computer programming
- Writing

More Advice from Richard Hamming

- Work on an important problem. Start with small problems that can become important.
- Change difficult situations and weaknesses into assets.
- Don't make excuses for yourself.