# CVXPY Exercises

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1. *Hello world.* Solve the following optimization problem using CVXPY:

$$\begin{array}{ll} \text{minimize} & x^2 - 2\sqrt{y} \\ \text{subject to} & 2 \geq e^x \\ & x + y = 5, \end{array}$$

   where $x, y \in \mathbf{R}$ are variables.

   Find the optimal values of $x$ and $y$.

2. *Non-negative least squares.* We wish to recover a sparse, non-negative vector $x \in \mathbf{R}^n$ from measurements $y \in \mathbf{R}^m$. Our measurement model tells us that

$$y = Ax + v,$$

   where $A \in \mathbf{R}^{n \times m}$ is a known matrix and $v \in \mathbf{R}^m$ is unknown measurement error. The entries of $v$ are drawn IID from the distribution $\mathcal{N}(0, \sigma^2)$.

   We can recover a good estimate of $x$ by solving the optimization problem

$$\begin{array}{ll} \text{minimize} & ||Ax - y||^2 \\ \text{subject to} & x \geq 0. \end{array}$$

   This problem is called non-negative least squares.

   The file `nnls.py` defines $n$, $m$, $A$, $x$, and $y$. Use CVXPY to estimate $x$ from $y$. First try standard regression, *i.e.*, solve

$$\text{minimize} \quad ||Ax - y||^2.$$

   Use the plotting code in `nnls.py` to compare the estimated $x$ with the true $x$. Add the constraint $x \geq 0$ and see how it affects the estimate.

   How many measurements $n$ are needed for standard regression to find an accurate $x$? How about non-negative least squares?

3. *Isotonic regression.* isotonic least squares

4. *Power grid optimization.*