ESE 605-001: Modern Convex Optimization **Spring 2020**

Homework 4

Assigned: 02/11/2020 *Due: 02/21/2020*

Homework must be LaTeX'd or it will not be graded.

Problems from Boyd & Vandenberghe: 4.1,4.4,4.6,4.11(a,c,d), 4.13, 4.16

Problems from additional exercises
`https://web.stanford.edu/~boyd/cvxbook/bv_cvxbook_extra_exercises.pdf`**:** A3.2, A3.3 (any 4 of the 8)

Bonus questions: Bonus questions are completely optional. If a certain threshold of correctness is exceeded, you will earn an additional 0.5 marks on your assignment grade. These are fun, challenging problems, and we ask that you try your best to get as far into the proofs/answers as you can *without consulting outside sources!* Once you get stuck, indicate the point at which you were stuck in your solutions with a "**I made it this far on my own**," after which, you should indicate what outside source you consulted in order to finish the problem, in accordance with the Penn Academic Integrity policy.

1. Show that minimizing the $\|Ax - b\|_4$ can be accomplished by solving a Quadratically Constrained Quadratic Program.
2. Show that the epigraph of any p-norm, for $p \geq 1$ a rational number, can be expressed as in terms of second order cone constraints.
3. Show that the hypograph of the geometric mean $K^2 := \left\{(x_1, x_2, t) \in \mathbb{R}^3 \,|\, x \geq 0,\, t \leq \sqrt{x_1 x_2}\right\}$ can be expressed in terms of second order cone constraints.