❶ **Note:** There are three problems which together are worth 50 points. Problem 1 is worth 17 points. Problem 2 is worth 20 points. Problem 3 is worth 13 points. Each Problem is graded using the Rubric described below which consists of an automatically assigned score based on the checks in CodeGrade, as well as manual grading by the TA.

The grade for the assignment G is calculated as

$$G = 1 + 9 \cdot \frac{\text{points reached}}{50}$$

1   Random Number Generation (17 points)

(a) **2 points:** 1 pt for passing the automatic check. 1 point for correct density expression for general μ, σ.

(b) **2 points:** 1 pt for passing the automatic check. 1 point for correct density expression for general μ, b.

(c) **3 points:** 1 pt for passing the automatic check. 1 point for correctly drawing uniform random numbers. 1 point for correctly transforming random number using the inverse CDF of the Cauchy distribution.

(d) **5 points:** 1 pt for passing the automatic check. 1 point for correctly using the function from (c) to draw Cauchy$(1, 1)$ random numbers. 1 point for correct uniform draws. 1 point for the correct formula/value for M. 1 point for a correct acceptance criterion.

(e) **5 points:** 1 point for passing the automated check (function runs). 1 point for drawing a histogram with 200 bins and 50,000 draws. 1 point for random draws approximating Laplace density. 1 point for correct x-axis limits. 1 point for correct overlay of theoretical Laplace density.

2   Numerical Optimization (20 points)

(a) **3 points:** 1 point for passing the automated check. 1 point for adding column of ones to the X matrix. 1 point for correct computation of the OLS estimator.

(b) **3 points:** 1 point for passing the automated check. 1 point for drawing a correct scatter plot of the data. 1 plot for drawing the correct fitted regression line.

(c) **2 points:** 1 point for passing the automated check. 1 point for correct computation of the normalized sum of absolute residuals.

(d) **2 points:** 1 point for passing the automated check. 1 point for correct computation of the gradient of the normalized sum of absolute residuals.

(e) **5 points:** 1 point for passing the automated check. 1 point for computing correct updating direction. 1 point for computing correct next potential **b** value. 1 point for correctly terminating backtracking procedure. 1 point for correctly updating function values and estimate of **b**.

(f) **3 points:** 1 point for passing the automated check. 1 point for drawing the correct scatter plot and fitted OLS regression line. 1 point for correctly computing the LAD estimator and plotting the fitted LAD regression line.

(g) **2 points:** 1 point for passing the automated check. 1 point for correctly using the Nelder-Mead function and returning $\hat{\beta}$.

3 Solving Linear Equations & Eigenvalues (13 points)

(a) **3 points:** 1 point for passing the automated check. 1 point for correct expression of **M**. 1 point for correct expression of **z**.

(b) **2 points:** 1 point for passing the automated check. 1 point for correctly applying function to compute $\hat{\beta}_{ridge}$.

(c) **2 points:** 1 point for passing the automated check. 1 point for correctly applying function to compute **w** and **V**.

(d) **3 points:** 1 point for passing the automated check. 1 point for using function from (c) to compute eigenvalues and eigenvectors, and modifying the vector of eigenvalues. 1 point for computing $\mathbf{M^{-1}}$.

(e) **3 points:** 1 point for passing the automated check. 1 point for using function from (d) to compute $\mathbf{M^{-1}}$. 1 point for using function from (a) to compute **z**.