

*Instructions:*

**Problem 1**

*Linear regression.*

1. Write down the minimization problem for multivariate binary linear regression and state the Newton-Raphson solution for the coefficients. Write down the standard likelihood for multivariate binary linear regression. Under what assumptions is the MLE stable ?
2. Write down the minimization problem for binary multivariate linear regression with a penalized loss, specifically the standard  $\ell_2$  shrinkage. Write down the posterior distribution for the standard binary linear regression problem with a standard shrinkage prior, you can leave the denominator as an integral.

**Problem 2**

*Nonlinear regression.*

1. Derive support vector machines from a geometric perspective and what is a support vector ?
2. Write out the posterior predictive distribution for a vector of unseen responses  $\mathbf{y}_*$  in a Gaussian process.
3. Write out the posterior predictive distribution for a vector of unseen responses  $\mathbf{y}_*$  in a Gaussian process with a linear kernel.

**Problem 3**

*Sparse regression.*

1. Write out the penalized loss function for LASSO and the  $\ell_0$  ideal penalized loss.
2. Write out pseudo code for LARS.
3. Provide an explanation as to why LASSO solutions can be sparse.
4. Derive the double exponential distribution as a scale mixture of normals.