

3. From running the experiments with a random  $x_0$ , the normal steepest descent took 18055 iterations, the preconditioned steepest descent took 1592 iterations, the normal CG took 233 iterations, and the preconditioned CG took 86 iterations. This was expected since preconditioning the system makes the contours much more "circular", which made the algorithms converge sooner. Also, the conjugate gradient method converged sooner than the steepest descent method since the conjugate gradient search directions are  $A$ -conjugate.