NLA: **Golub** for $k = 1 : m, n$: $u_k = (sgn(b_{k,k})\|b_{k:m,k}\|e_1 + b_{k:m,k})$; $u_k := \hat{u}_k$; $U_k := I - 2u_k u_k^T$; $B_{k:m,k:n} := U_k B_{k:m,k:n}$; $U = [I_{k-1,k-1}, 0; 0, U_k]$;for $j = 1 : m, n-1$: $v_k^T := sgn(b_{k,k+1})\|b_{k,k+1:n}\|e_1 + b_{k:m,k}$;$V_k := I - 2v_k v_k^T$; $B_{1:m,k+1:n} = B_{1:m,k+1:n} V_k$; $V = [I_{k,k}, 0; 0, V_k]$endfor endfor; $2 \cdot (2mn^2 - 2n^3/3)$ **Householder** for $k = [1, n] : x = A_{k:m,k}$; $v_k = sgn(x)\|x\|e_k + x$; $v_k = \frac{v_k}{\|v_k\|}$ for $j = [k, n]$ $A_{k:m,j} = A_{k:m,j} - 2v_k\,[v_k^* A_{k:m,j}]$ endfor endfor. $2mn^2 - \frac{2n^3}{3}$. **MG-S** $V = A$;for $i = [1, n] : r_{ii} = \|v_i\|$; $q_i = \frac{v_i}{r_{ii}}$;for $j = [i+1, n]$ $v_j = v_j - (q_i^T v_j) q_i$; $r_{ij} = q_i^T v_j$ endfor endfor. $2mn^2$. **Arnoldi:** $q_1 := \hat{b}$; $q_{k+1} h_{k+1,k} = Aq_k - \sum_{i=1}^{k} q_i h_{ik}$; $h_{ik} = q_i^T (Aq_k)$; $h_{k+1,k} := \|v\| \to AQ_k := Q_k H_k + q_{k+1}[0 \dots h_{k+1,k}]$. **Givens** $3mn^2$ **SVD:** $= \sum_i^{r:=\min m,n} u_i \sigma_i v_i^T$. **QR Algo:** $A_{k+1} = Q_k^T A_k Q_k \to A_{k+1} = \left(Q^{(k)}\right)^T A Q^{(k)} \& A^k = (Q_1 \dots Q_k)(R_k \dots R_1) := Q^{(k)} R^{(k)}$, via induction **Bounds:** $\left\|ABB^{-1}\right\| \geq \|AB\|\left\|B^{-1}\right\| \to \|A\|/\left\|B^{-1}\right\| \geq \|AB\|$. **Weyls:** $\sigma_i(A + B) = \sigma_i(A) + [-\|B\|, \|B\|]$ **Rev Δ Ineq:** $\|A - B\| \geq |\|A\| - \|B\||$ **Courant Application:** $\sigma_i\left([A_1; A_2]\right) \geq \max\left(\sigma_i(A_1), \sigma_i(A_2)\right)$ **Schur:** Take $Av_1 = \lambda_1 v_1$; construct $U_1 = [v_1, V_\perp] \to AU_1 = U_1[e_1, X]$. Repeat. **Conditioning** $\kappa_2(A) = \sigma_1/\sigma_n = \|A\|\left\|A^{-1}\right\|$ **Similarity:** $A \to P^{-1}AP$, same λ.

NPDE: **Def'n:** With $u_{tt} - c^2 u_{xx} = f$ have $\Delta x = (b-a)/J, \Delta t = T/M, x_j = a + j\Delta x, t = m\Delta t$. I.C: $U_j^0 = u_0(x_j), U_j^1 = U_j^0 + u_1(x_j)\Delta t, U_0^m = U_J^m = 0$