

functional matrix identities, 608  
 functions of  
   diagonalizable matrices, 526  
   of Jordan blocks, 600  
   matrices, 601  
     using Cauchy integral formula, 611  
     using Cayley–Hamilton theorem, 614  
   nondiagonalizable matrices, 603  
 fundamental (normal) mode of vibration, 562  
 fundamental problem of matrix theory, 506  
 fundamental subspaces, 169  
   dimension of, 199  
   orthonormal bases for, 407  
   projector onto, 434  
 fundamental theorem of algebra, 185, 492  
 fundamental theorem of linear algebra, 405

**G**

gap, 453, 454  
 Gauss, Carl F., ix, 2, 93, 234, 488  
   as a teacher, 353  
 Gaussian elimination, 2, 3  
   and LU factorization, 141  
   effects of roundoff, 129  
   modified, 43  
   numerical stability, 348  
   operation counts, 10  
 Gaussian transformation, 341  
 Gauss–Jordan method, 15, 47, 48  
   for computing a matrix inverse, 118  
   operation counts, 16  
 Gauss–Markov theorem, 229, 448  
 Gauss–Seidel method, 622  
 general solution  
   algebraic equations  
     homogeneous systems, 59, 61,  
       nonhomogeneous systems, 64, 66, 70, 180, 221  
   difference equations, 616  
   differential equations, 541, 609  
 generalized condition number, 426  
 generalized eigenvalue problem, 571  
 generalized eigenvectors, 593, 594  
 generalized inverse, 221, 393, 422, 615  
   Drazin, 399  
   group, 402  
   and orthogonal projectors, 434  
 generalized minimal residual (GMRES), 655  
 genes and chromosomes, 543  
 geometric multiplicity, 510  
 geometric series, 126, 527, 618  
 Gerschgorin circles, 498  
 Gerschgorin, S. A., 497  
 Givens reduction, 344  
   and determinants, 485  
   numerical stability, 349  
 Givens rotations, 333  
 Givens, Wallace, 333

GMRES, 655  
 Golub, Gene H., xii  
 gradient, 570  
 Gram, Jorgen P., 307  
 Gram matrix, 307  
 Gram–Schmidt algorithm  
   classical version, 309  
   implementations of, 319  
   and minimum polynomial, 643  
   modified version, 316  
   numerical stability of, 349  
   and volume, 431  
 Gram–Schmidt process, 345  
 Gram–Schmidt sequence, 308, 309  
 graph, 202  
   of a matrix, 209, 671  
 graphics, 3-D rotations, 328, 330  
 Grassmann, Hermann G., 160  
 Graybill, Franklin A., xii  
 grid norm, 274  
 grid points, 18  
 group, finite, 676  
 group inverse, 402, 640, 641  
 growth in Gaussian elimination, 26  
 Guttmann, L., 124

**H**

Hadamard, Jacques, 469, 497  
 Hadamard's inequality, 469  
 Halmos, Paul, xii, 268  
 Hamilton, William R., 509  
 harmonic functions, 563  
 Haynsworth, Emilie V., 123  
 heat equation, 563  
 Helfrich, Laura, xii  
 Hermite, Charles, 48  
 Hermite interpolation polynomial, 607  
 Hermite normal form, 48  
 Hermite polynomial, 231  
 hermitian matrix, 85, 409, 410  
   condition of eigenvalues, 552  
   eigen components of, 549  
 Hessenberg matrices 350  
   QR factorization of, 352  
 Hessian matrix, 570  
 Hestenes, Magnus R., 656  
 hidden surfaces, 332, 339  
 Hilbert, David, 307  
 Hilbert matrix, 14, 31, 39  
 Hilbert–Schmidt norm, 279  
 Hohn, Franz, xii  
 Hölder, Ludwig O., 278  
 Hölder's inequality, 274, 277, 278  
 homogeneous systems, 57, 61  
 Hooke, Robert, 86  
 Hooke's law, 86  
 Horn, Roger, xii