Index

1s-complement, 146	conductance matrix, 269	Cauchy-Schwarz inequality, 111,
	counting paths in graphs, 12	121, 242
A	cubic splines, 252	matched filter, 112
A-conjugate, 497	electric circuit with inductors, 89	characteristic
A-norm, 275, 497	electrical circuit, 39	equation, 79
absolute error, 150	encryption, 71	polynomial, 79, 182
adaptive procedure, 314	finite difference approximations, 244	Chebyshev
adjacency matrix, 13	Fourier series, 241	polynomial, 258, 583
adjoint, 63, 71	image compression using the SVD, 310	Cholesky
algorithm, 163	instability of the Cauchy problem, 188	decomposition, 270
backward stable, 185	least-squares fitting, 247	incomplete decomposition, 503
Big-O notation, 167	least-squares to fit a power function, 328	Chris Paige, 546
Cholesky decomposition, 271	Leslie model, 383	clamped cubic spline, 255
colon notation, 214	Poisson's equation, 478	classical
computing the Givens parameters, 358	signal comparison, 112	Gram-Schmidt, 284
cubic, 167	team ranking, 94	Jacobi method, 444, 465
forward stable, 186	truss, 37	coefficient matrix, 4, 27
Frobenius norm, 164	velocity of an enzymatic reaction, 331	cofactor, 62
Givens QR decomposition, 360	vibrating masses on springs, 380	colon notation, 214
Gram-Schmidt, 282	Argand diagram, 571	column
implicit QR, 409	Arnoldi decomposition, 509	rank, 322
inner product, 164	Arnoldi process, 534	space, 48
inner product of two vectors, 164	augmented matrix, 27	vector, 7
iterative improvement, 229		compatible norms, 141
linear, 167		complex numbers, 569
LU decomposition, 214	В	Argand diagram, 571
LU decomposition of a tridiagonal matrix,	back substitution, 29, 168, 207	complex plane, 571
264	backward	conjugate, 571
LU decomposition without a zero on the	error, 184, 587	imaginary part, 569
diagonal, 216	stable, 185	rationalization of the denominator,
modified Gram-Schmidt, 285	band matrix, 238	570
product of a Givens matrix with a general	basic QR iteration, 394	real part, 569
matrix, 356	basis, 50	square root, 570
product of two matrices, 164	local, 125	complex plane, 571
pseudocode, 163	orthonormal, 122	imaginary axis, 571
quadratic, 167	Bauer-Fike theorem, 424	lower half, 571
recursion stopping condition, 459	bi-conjugate gradient method, 531	real axis, 571
solve AX = B using LU factorization, 225	bidiagonal matrix, 44, 263	upper half, 571
solve $Ax = b$ using EO factorization, 223 solve $Ax = b_i$, $1 \le i \le k$, 225	Big-O notation, 167	compressed row storage format, 492
solving a lower-triangular system, 170	biharmonic equation, 523	condition number, 143, 189, 192
solving a lower-triangular system, 170 solving an upper-triangular system, 169	biorthogonal bases, 528	estimate, 195
solving the least-squares problem using the	bit, 145	conjugate gradient method, 493
QR decomposition, 328	block	conjugate transpose, 117
solving the least-squares problem using the	pentadiagonal matrix, 523	contour lines, 494
SVD, 330	tridiagonal matrix, 522	Cramer's rule, 69, 182
stability, 186	bulge, 411	critical loads, 388
steepest descent, 496	bulge, 411	cross product, 115, 177
the power method, 391		Crout's Method, 233
unstable, 185	C	CRS format, 492
	cancellation error, 155	cubic algorithm, 167
angle between vectors, 107	carry, 146	cubic algorithm, 107 cubic spline, 252
applications biharmonic equation, 523	Cauchy problem, 188	clamped, 255
omarmonic equation, 323	Cauchy problem, 100	Ciampeu, 255

cubic spline (Continued)	generalized problem, 432	F
natural, 255	ghost, 546, 549	Feynman, Richard, 575
not-a-knot condition, 255	implicit double shift, 415	Fibonacci
cyclic-by-row Jacobi algorithm, 444	implicit Q theorem, 410	matrix, 12
	implicitly restarted Arnoldi	sequence, 12
D	method, 540	filtering polynomial, 540
	inverse power method, 393	finite difference equations, 246
deflation, 401	Jacobi method, 440	first buckling mode, 388
determinant, 15	of a symmetric matrix, 134	five-point
and the matrix inverse, 67	power method, 390, 428, 533	difference approximation, 480
Cramer's rule, 69	•	**
diagonal matrix, 61	convergence, 391	stencil, 480 fl, 148
first-row Laplace expansion, 60	QR iteration, 394	
general expansion by minors, 62	rate of convergence of power	floating point, 147
lower triangular matrix, 61	method, 392	absolute error, 150
matrix with row of zeros, 61	Rayleigh	arithmetic, 150
properties for evaluation, 64	quotient, 389	avoiding error, 155
upper triangular matrix, 61	quotient iteration, 465	base, 147
using QR decomposition, 291	quotient shift, 404	bias, 148
Devlin, Keith, 575	sensitivity of perturbations, 424	granularity, 149
diagonal	shift, 404	IEEE arithmetic, 151
dominance, 172, 477	single shift QR algorithm, 404	mantissa, 147
matrix, 61	strictly interlacing, 455	normalization, 155
diagonalizable matrix, 84	eigenvector	overflow, 148
diagonally dominant matrix, 263	-	relative error, 150
digraph, 92	computing	round-off error, 151
strongly connected, 93	from eigenvalue, 420	rounding, 149, 151
dimension of a subspace, 51	the largest, 391	rounding error in matrix multiplication, 154
directed line segments, 103	the smallest, 393	rounding error in scalar multiplication, 154
direction vector, 494	definition, 80	truncation, 151
distance between points, 103	eigenspace, 83	underflow, 148
*	left, 425	flop, 167
dominant eigenvalue, 389	localization, 466	count, 167
dot product, 105	matrix, 86, 389	force vector, 381
drop tolerance, 505	sensitivity, 427	forward
	shifted inverse iteration, 421	
E	electric circuit	error, 183
eigenfunctions, 388	Kirchhoff's current law, 39	stable, 186
eigenspace, 83	Kirchhoff's voltage law, 39	substitution, 169, 206
eigenvalue	elementary	Fourier
and vibrations, 380	row matrix, 208	coefficients, 242
Bauer-Fike theorem, 424		Fourier series, 241
characteristic	row operations, 27	Gibbs phenomenon, 260
equation, 79	ellipsoid, 307	sawtooth wave, 257
polynomial, 79, 182	encryption, 71	square wave, 243
classical Jacobi method, 444, 465	example, 72	triangle wave, 258
condition number, 426	energy norm, 275, 497	Francis algorithm, 409
cyclic-by-row Jacobi algorithm, 444	eps, 149	degree one, 409, 452
definition, 79	error	degree two, 413
	absolute, 150	double shift, 409
deflation, 401	backward, 184, 587	single shift, 409
deflation using the implicit double	cancellation, 155	Frobenius norm, 127, 128
shift, 420	forward, 183	full reorthogonalization, 517
dominant eigenvalue, 389	relative, 150	fundamental frequency, 380
eig function, 95	round-off, 117, 145	1 7
eigb function, 423	truncation, 145	C
eigenspace, 83	Euclidean norm, 120	G
eigqr function, 402		Gauss transformation matrix, 235
eigqrshift function, 405	Euler's	Gauss-Seidel
eigsb function, 542	formula, 575	iteration, 470
eigssymb function, 546	identity, 575	matrix form, 473
explicit	Euler-Lotka equation, 385	Gaussian elimination, 26, 29
double shift, 415	expansion by minors, 60, 62	procedure, 29
restart for large sparse problem, 536	explicit	stability, 227
filtering polynomial, 540	restart, 536	with complete pivoting, 226
Francis algorithm, 409	shift, 415	with partial pivoting, 218
Francis iteration of degree one, 409	extrapolation, 248	GECP, 226
<i>E</i> ,	* · · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·

generalized eigenvalue problem, 432	incomplete	least-squares, 248, 321
geometric series, 580	Cholesky decomposition, 503	geometric interpretation, 321
GEPP, 218	LU decomposition, 514	linear, 321
Gergorin's disk theorem, 431	inconsistent system of linear equations, 25, 31	normal equations, 249, 322
ghost eigenvalues, 546, 549	induced matrix norm, 127	overdetermined system, 249
Gibbs phenomenon, 260	induction	rank deficient, 333
Givens	basis step, 579	regression line, 250
matrix, 352	inductive step, 579	residual, 248
method, 351	initial-boundary value problems, 245	residual equation, 324
parameters, 358	inner product, 104, 589	solution using normal equations, 326
QR decomposition algorithm, 360	geometric interpretation, 105	underdetermined system, 249
rotation, 353	properties, 105	use of Cholesky decomposition, 326
GMRES, 512	integer, 7	using QR decomposition, 327
golden ratio, 88	•	using the SVD, 329
gradient of a function, 494	largest positive, 146	
Gram-Schmidt	most negative, 147	weighted, 343
orthonormalization, 283	overflow, 147	left
	representation, 145	eigenvector, 425
process, 281, 282	interpolation, 248	nullspace, 57
QR decomposition, 288, 351	inverse	preconditioner, 502
granularity of floating point numbers, 149	computation, 34	singular vectors, 301
graph, 12	computation using the adjoint, 63	Leslie
adjacency matrix, 13	iteration, 420	matrix, 383
edges, 12	of a matrix product, 14	model, 383
number of paths between two vertices, 13	participation ratio, 467	level set, 494
path, 12	power method, 393	linear
vertices, 12	invertible matrix, 13	algorithm, 167
growth factor, 227	irrational number, 7	combination, 48
guard digit, 150	irreducible matrix, 92	equation, 25
	iterative methods, 469	interpolation, 252
Н	conjugate gradient, 497	splines, 252
Hanowa matrix, 101	drop tolerance, 505	transformation, 7
heat equation, 245	Gauss-Seidel, 470	translation, 9
Hermitian	GMRES, 512	linear system
matrix, 117, 573	implicitly restarted Arnoldi, 540	consistent, 25
	implicitly restarted Lanczos, 544	homogeneous, 15
transpose, 413	Jacobi, 469	inconsistent, 25, 31
Hessenberg	MINRES, 519	trivial solution, 15
lower, 396	power method, 390, 533	linearly
upper, 396	SOR, 471	dependent, 49
Hilbert	steepest descent, 493	independent, 49
matrices, 22, 77	iterative refinement, 228	local basis, 125
space, 242	herative remement, 226	lower-triangular matrix, 169
Hilbert-Schmidt norm, 127		LU
homogeneous system, 15, 36	J	
nontrivial solution, 36	Jacobi	decomposition, 205, 206
trivial solution, 36	iteration, 469	decomposition algorithm, 214
Householder	matrix form of iterative method, 473	
method, 351	method for computing eigenvalues, 440	M
reflection, 362	preconditioner, 527	machine precision, 149
	sweep, 444	mantissa, 147
I	<u>F</u> ,	MATLAB function
identity matrix, 11	•/	chol, 271
IEEE	K	cond, 195, 325
arithmetic, 151	Kirchhoff's rules, 39	condest, 196
floating point standard, 148	knot, 252	det, 62
ill-conditioned	Krylov	eig, 95
	sequence, 508	<u> </u>
matrix, 119	subspace, 508	fix, 162
problem, 187	-	gallery, 192
imaginary part of complex number, 569	1	gmres, 513
implicit 415	L	help, 162
double shift, 415	L^2	ichol, 505
Q theorem, 410	inner product, 110	ilu, 515
QR algorithm, 409	norm, 281	inv, 15
single shift, 409	Lagrange interpolation, 252	lu, 225
implicitly restarted Arnoldi method, 540	Lanczos method, 516	minres, 531

MATLAB function (Continued)	left	square root, 317
norm, 121	nullspace, 57	SSOR preconditioner, 506
qr, 289	preconditioner, 502	stiffness, 381
rand, 57	lower triangular, 169	strictly column diagonally dominant, 234
rank, 53	LU decomposition, 205, 206	strictly row diagonally dominant, 477
realmin, 162	negative of a matrix, 2	subordinate norm, 127
schur, 408	nonnegative, 93	subtraction of matrices, 2
svd, 308	nonsingular, 13	superdiagonal entries, 263
symmlq, 531	normal, 431	SVD, 53, 299
trace, 6	null space, 47	symmetric, 17
transpose, 17	null space using SVD, 303	the zero matrix, 2
vectorization, 6	off diagonal entries of a square matrix, 20	Toeplitz, 203, 513
wilkinson, 452	orthogonal	trace, 5
zeta, 577	and conditioning, 195	transpose, 16
matrix, 1	invariance, 136	tridiagonal, 20, 44, 171, 236, 247, 263
1-norm, 131	overdetermined system, 321	underdetermined system, 321, 338
2-norm, 132	partial pivoting, 218	unitary, 576
addition, 2	pencil, 432	unreduced Hessenberg, 400
addition, 2 adjoint, 63	pentadiagonal, 489	upper
and orthogonal vectors, 108	permutation, 218	bidiagonal, 172
		triangular, 29, 168, 359
and system of equations, 4	Perron-Frobenius theorem, 93	upper triangular, 72
back substitution, 29, 207	pivot, 218	Vandermonde, 67, 203, 248
band, 238	positive definite, 44, 267	well-conditioned, 440
bidiagonal, 44, 263	positive semidefinite, 267	McLaurin series, 575
block	power, 11	MGS, 288
pentadiagonal, 523	preconditioner, 501	Millennium Bridge, 79
structured, 101	product, 2	minimum residual method (MINRES), 519
tridiagonal, 522	proper	minor, 60
Cholesky decomposition, 270	Hessenberg, 400	mode of an image, 311
coefficient matrix, 4	orthogonal, 109	modified Gram-Schmidt
cofactor, 62	properties of the condition number, 193	process, 285
column rank, 322	pseudoinverse, 324	
computational expense, 3	QR decomposition, 351	QR decomposition and ill-conditioned
computing the inverse, 34	quasi-triangular, 408	matrices, 351
condition number, 143, 192	range, 57	monic polynomial, 584
conjugate transpose, 117	range using SVD, 303	Moore-Penrose generalized inverse, 324
Crout 's Method, 233	rank, 51, 322	
decomposition, 206	deficient, 57	N
diagonal dominance, 172	revealing QR decomposition, 296	natural
diagonalizable, 84	using SVD, 302	cubic splines, 255
diagonally dominant, 263	rank 1, 310	frequency, 381
elementary row, 208	real Schur form, 408	nonnegative matrix, 93
equality of matrices, 2	reduced QL decomposition, 375	norm
factoring a tridiagonal matrix, 264	reducible, 92	1-norm, 120
factorization, 43	reversal matrix, 375	A-norm, 275, 497
forward substitution, 206	reverse identity, 375	energy norm, 275, 497
Frobenius norm, 128	right preconditioner, 502	Frobenius, 127, 128
full rank, 287	rotation, 7, 8, 10	Hilbert-Schmidt, 127
Gauss transformation, 235	row	induced matrix norm, 127
Gaussian elimination with partial pivoting,	rank, 322	infinity norm, 120
218	space, 48	p-norm, 120
Givens, 352	row-equivalent matrices, 28	Schatten p-norm, 141
rotation, 353	scalar multiple of a matrix, 2	sub-multiplicative, 131
	<u>.</u>	normal
growth factor, 227	Schur's triangularization, 405	derivative, 523
Hanowa, 101	similar, 84	equation of a plane, 115
Hermetian transpose, 413	simple eigenvector, 93	equations, 249, 322
Hermitian, 117, 573	singular, 13	matrix, 431
identity, 11	singular value decomposition, 53, 299	not-a-knot condition, 255
ill-conditioned, 22, 119	singular values, 133, 135, 182, 307	null space, 47
inverse, 13	sparse, 38, 171, 247, 469	nan space, 17
of a product, 14	sparsity pattern, 491	
invertible, 13	spectral theorem, 136	O
irreducible, 92	split preconditioner, 502	one's-complement, 159
laws of arithmetic, 3	square matrix diagonal, 20	one-sided Jacobi algorithm, 551

optimal upper bound, 192	Gram-Schmidt method for	row
		equivalent matrices, 28
orthogonal	computing, 287	rank, 322
complement, 316	Householder's method for	space, 48
invariance, 121, 136	computing, 351	•
matrix, 195	iteration for computing	Runge's phenomenon, 262
projection, 282	eigenvalues, 394	
similarity transformation, 396	reduced, 289	S
vectors, 107, 281	theorem, 351	sawtooth wave, 257
orthonormal	quadratic	
basis, 122	algorithm, 167	scaling, 120, 126
vectors, 108	form, 22, 267	Schatten p-norm, 141
	formula, 155	Schur's triangularization, 405
outer product, 116, 184		secular equation, 460
overdetermined system, 249, 321	function, 493	shifted inverse iteration, 420
overflow, 147, 148	quadratic spline, 259	signal comparison, 112
	quasi-triangular matrix, 408	significant digits, 147
P		similar matrices, 84
	R	simple eigenvector, 93
p-norms, 120		single shift, 404
PageRank process, 94	rank, 51	
parallelogram law, 103	1 correction, 459	singular matrix, 13
partial pivoting, 218	1 matrix, 310	singular value decomposition, 53
Peirce, Benjamin, 575	1 update, 374	geometric interpretation, 307
permutation matrix, 116, 218	deficient matrix, 57	left singular vectors, 301
perpendicular vectors, 107	revealing QR	right singular vectors, 301
Perron-Frobenius theorem, 93	decomposition, 296	theorem, 299
	rational number, 7	singular values, 133, 135, 182, 307
pessimistic upper bound, 192	Rayleigh	artificial ill-conditioning, 557
pivot, 211	quotient, 389	Demmel and Kahan zero-shift QR downward
matrix, 218	•	sweep, 558
Poisson's equation, 478	quotient iteration, 465	*
polar decomposition, 320	quotient shift, 404	one-sided Jacobi algorithm, 551
poles in divide-and-conquer, 460	real part of complex number, 569	SOR iteration, 471
position vector, 103	real Schur form, 408	sparse matrix, 38, 171, 247
positive definite matrix, 44, 267	recursive definition, 60	Arnoldi decomposition, 509
positive semidefinite matrix, 267	red-black ordering, 486	CRS format, 492
•	reduced	GMRES, 512
positivity, 120, 126	QL decomposition, 375	Lanczos decomposition, 516
power method, 390, 428, 533	QR decomposition, 289	minimum residual method (MINRES), 519
convergence, 391	SVD, 329	sparsity pattern, 491
inverse, 393	reducible matrix, 92	spectral
rate of convergence, 392		*
power of a matrix, 11	regression line, 250	norm, 132
preconditioned	relative	radius, 137
CG, 503	error, 150	theorem, 136, 439
GMRES, 514	residual, 470	spline
preconditioner, 501	relaxation parameter, 471	cubic, 252
CG	reorthogonalization, 297	knot, 252
incomplete Cholesky, 503	full, 517	quadratic, 259
•	residual, 248	split preconditioner, 502
SSOR, 506	resonance, 382	square root of a matrix, 317
GMRES	reversal matrix, 375	square wave, 243
incomplete LU decomposition, 514	reverse identity matrix, 375	SSOR preconditioner, 506
Jacobi, 527	•	•
preconditioning, 501	Riemann	for GMRES, 527
projection operator, 281	hypothesis, 577	stability, 186
proper	zeta function, 576	standard basis vectors, 49
Hessenberg, 400	right	steady state, 91
orthogonal matrix, 109	preconditioner, 502	steepest descent, 493, 496
_	singular vectors, 301	stiffness matrix, 381
pseudocode, 163	Ritz	stopping condition, 459
pseudoinverse, 324	eigenvector, 535	strictly
Pythagorean Theorem, 121, 141	locked pair, 537	column diagonally dominant, 234
	pair, 535	interlacing eigenvalues, 455
Q	<u> -</u>	
	value, 535	strong induction, 580
QMR method, 532	root, 453	strongly connected digraph, 93
QR decomposition, 287, 351	rotation matrix, 7, 8, 10	Sturm sequence, 455
full, 289	round-off error, 117, 145, 149	sub-multiplicative norm, 131
Givens method for computing, 351	rounding, 148, 149, 151	subordinate matrix norm, 127

basis, 50 dimension, 51 Krylov, 508 Gauss-Seidel iteration, 470 Grave Gauss-Seidel iteration, 470 Grave Gauss-Seidel iteration, 470 Grave Gauss-Seidel iteration, 470 Grave Gauss-Geidel iteration, 469 Luc decomposition, 205 Luc decomposition, 205 MRES method, 519 relative residual, 470 solution using the inverse, 15 SOR iteration, 471 vector of constants, 4 vector of constants, 4 vector of constants, 4 vector of unknowns, 4 vector of unknowns, 4 vector of unknowns, 4 vector, 10 Vandermonde matrix, 27, 20, 204 Vandermonde matrix, 29, 168, 359 Vandermonde matrix, 27 cross product, 115 norm, 119 of constants, 4 of unknowns, 4 of unk	subspace, 47	conjugate gradient method, 493	sphere of a norm, 128
Krylov, 508 orthogonal complement, 316 spanned by, 48 homogeneous, 36 superdiagonal matrix entries, 263 superdiagonal matrix, 27 spanned by, 48 homogeneous, 36 superdiagonal matrix entries, 263 superdiagonal matrix entries, 263 superdiagonal matrix, 299 MINESS method, 519 relative residual, 470 solution using the inverse, 15 soft iteration, 471 vector of constants, 4 vector of constants, 4 vector of unknowns, 4 vector, 1 column, 7 cross product, 115 norm, 119 of constants, 4 vector, 1 read, 115 norm, 119 of constants, 4 ve	basis, 50	elementary row operations, 27	vector, 108
orthogonal complement, 316 spanned by, 48 superdiagonal matrix entries, 263 superdiagonal matrix entries, 263 Jacobi iteration, 469 LU decomposition, 205 SVD, 53, See singular value decomposition, 299 Sylvester's criterion, 267 symmetric matrix, 17 A ^T A, 133 Sibiarmonic, 523 bisaction method for computing eigenvalues, 453 divide-and-conquer method for computing eigenvalues, 452 bis eigenvalues, 134 Francis method for computing eigenvalues, 451 minearly independent eigenvalues, 452 Larcox decomposition of, 516 listing of important properties, 440 Lancox decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 449 skew, 432 spectral theorem for, 439 Larcox decomposition, 299 MINISmos 21 x 21 matrix, 452 system of linear equation, 4 augmented matrix, 27 unit of the decical on a radiagonal matrix, 27 unit of the special polynomial, 187 shift, 451 augmented matrix, 27 unit of the special polynomial, 187 shift, 451 augmented matrix, 27 unit of the monogeneous, 36 homogeneous, 36 has reinclosed decomposition, 205 hidiagonal matrix, 492 unreduced Hessenberg, 400 unustable algorithm, 185 upper bidiagonal matrix, 27 sunction, 469 unustable algorithm, 185 upper bidiagonal matrix, 29, 168, 359 values, 452 bidiagonal matrix, 470 traingle merce, 15 SOR iteration, 471 vector of constants, 4 vector of unknowns, 4 vector of unknowns, 4 vector of unknowns, 4 vector, 10 rollman, 7 collman, 7 c	dimension, 51	Gauss-Seidel iteration, 470	unitary matrix, 576
spanned by, 48 superdiagonal matrix entries, 263 superemum, 189 SVD, 53, See singular value decomposition, 299 Sylvester's criterion, 267 Sylvester's criterion, 277 Tacama Narrows Bridge, 79 collapse, 380 tensor product, 116, 176 thermal diffusivity, 245 Tocplitz matrix, 203, 513 trace, 5 transient solution, 91 trace, 5 transient solution, 91 trace, 5 transient solution, 91 transpose of a matrix, 16 triangle inequality, 1	Krylov, 508	Gaussian elimination, 26, 29	Univ. of Florida Sparse Matrix
superdiagonal matrix entries, 263 supremum, 189	orthogonal complement, 316	GMRES method, 512	Collection, 492
Supremum, 189 SVD, 53, See singular value decomposition, 299 SVD, 53, See singular value decomposition, 299 Sylvester's criterion, 267 symmetric matrix, 17 A ^T A, 133 biharmonic, 523 bisection method for computing eigenvalues, 453 divide-and-conquer method for computing eigenvalues, 458 eigenvalues, 154 Francis method for computing eigenvalues, 459 has ral eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 sysetral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 LU column, 7 cross product, 115 norm, 119 of constants, 4 of unknowns, 4 of unk	spanned by, 48	homogeneous, 36	unreduced Hessenberg, 400
SVD, 53, See singular value decomposition, 299 Sylvester's criterion, 267 Sylvester's criterion, 267 Synmetric matrix, 17 A ^T A, 133 biharmonic, 523 bisection method for computing eigenvalues, 453 divide-and-conquer method for computing eigenvalues, 453 divide-and-conquer method for computing eigenvalues, 458 Francis method for computing eigenvalues, 459 has n linearly independent eigenvalues, 434 Hilbert, 201 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 MINRES method, 519 relative residual, 470 solution using the inverse, 15 SOR iteration, 471 vector of constants, 4 vector of unknowns, 4 Vandermonde matrix, 29, 168, 359 Vandermonde matrix, 29, 208, 248 vector, 1 column, 7 cross product, 115 norm, 119 of constants, 4 of unknowns, 4 of unknowns, 4 of unknowns, 4 of unknowns, 4 operations, 103 orthogonal vectors, 107, 203 orthogonal vector, 107 triangular matrix, 29, 168, 359 Vandermonde matrix, 67, 203, 248 vector, 1 column, 7 cross product, 115 norm, 119 of constants, 4 operations, 103 orthogonal vectors, 107 perpendicular vectors, 107, 281 orthonormal set of, 108 outer product, 116 parallel vectors, 107 unit, 108 vectorization, 6 vibration problem, 380 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 augmented matrix, 279	superdiagonal matrix entries, 263	Jacobi iteration, 469	unstable algorithm, 185
Sylvester's criterion, 267 symmetric matrix, 17 A ^T A, 133 biharmonic, 523 bisection method for computing eigenvalues, 453 divide-and-conquer method for computing eigenvalues, 458 eigenvalues, 134 Francis method for computing eigenvalues, 452 has n linearly independent eigenvalues, 451 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 relative residual, 470 solution using the inverse, 15 SOR iteration, 471 vector of constants, 4 Vandermonde matrix, 67, 203, 248 vector, 1 column, 7 cross product, 115 norm, 119 of constants, 4 of unknowns, 103 orthogonal vectors, 107, 281 orthonormal set of, 108 outer product, 116 parallel vectors, 107 perpendicular vectors, 107 unit, 108 vectorization, 6 vibration problem, 380 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 augmented matrix, 27 unit, 198 bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 augmented matrix, 27	supremum, 189	LU decomposition, 205	upper
symmetric matrix, 17 A ^T A, 133 biharmonic, 523 bissection method for computing eigenvalues, 453 divide-and-conquer method for computing eigenvalues, 458 eigenvalues, 134 Francis method for computing eigenvalues, 452 has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 440 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 solution using the inverse, 15 SOR iteration, 471 vector of constants, 4 vector of unknowns, 4 vector, 1 column, 7 cross product, 115 norm, 119 of constants, 4 operation, 7 troops reduct, 116, 176 thermal diffusivity, 245 Toeplitz matrix, 203, 513 trace, 5 transient solution, 91 transpose of a matrix, 16 triangle wave, 258 tridiagonal matrix, 16 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 37 welfor of unknowns, 4 vector, 1 column, 7 cross product, 115 norm, 119 of constants, 4 operation, 6 vibralomental, 19 vector of unknowns, 4 vector, 1 column, 7 cross product, 115 norm, 119 of constants, 4 operation, 47 vector of unknowns, 4 vector, 1 column, 7 cross product, 116, 176 thermal diffusivity, 245 Toeplitz matrix, 203, 513 trace, 5 transient solution, 91 transpose of a matrix, 20, 44, 236, 247, 263 trivial solution, 91 transpose of a matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 187 williamental matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 187 williamental matrix, 20,	SVD, 53, See singular value decomposition, 299	MINRES method, 519	bidiagonal matrix, 172
bisection method for computing eigenvalues, 453 divide-and-conquer method for computing eigenvalues, 453 divide-and-conquer method for computing eigenvalues, 454 eigenvalues, 134 Francis method for computing eigenvalues, 455 has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4 augmented matrix, 27 SOR iteration, 471 vector of constants, 4 vector of unknowns, 4 vector of unknowns, 4 Vandermonde matrix, 67, 203, 248 vector, 1 column, 7 cross product, 115 norm, 119 of constants, 4 of unknowns, 4 operations, 103 orthogonal vectors, 107, 281 orthonormal set of, 108 outer product, 116 parallel vectors, 107 perpendicular vectors, 107 unit, 108 vectoral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 SOR iteration, 471 vector of constants, 4 vector of unknowns, 4 Vandermonde matrix, 67, 203, 248 vector, 1 column, 7 cross product, 115 norm, 119 of constants, 4 of unknowns, 4 operations, 103 orthogonal vectors, 107, 281 orthonormal set of, 108 outer product, 116 parallel vectors, 107 unit, 108 vectorization, 6 vibration problem, 380 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99	Sylvester's criterion, 267	relative residual, 470	triangular matrix, 29, 168, 359
biharmonic, 523 bisection method for computing eigenvalues, 453 divide-and-conquer method for computing eigenvalues, 458 eigenvalues, 134 Francis method for computing eigenvalues, 452 has n linearly independent eigenvalues, 454 liiblert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 449 reduction to a tridiagonal matrix, 449 skew, 432 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 vector of constants, 4 vector of unknowns, 4 Vandermonde matrix, 67, 203, 248 vector, 1 column, 7 cross product, 115 norm, 119 of constants, 4 of unknowns, 4 of unknowns, 4 of unknowns, 4 of unknowns, 1 roros, product, 116 of unknowns, 1 roros, product, 116 of unknowns, 4 of unknowns, 1 of unknowns, 4 of unknowns, 1 of unknowns, 1 of unknowns, 1 of unknowns, 1 of unknowns, 2 of unknowns, 2 of unknowns, 3 of unknowns, 4 of unknowns, 1 of unknowns, 4 operations, 103 orthogonal vectors, 107, 281 orthonormal set of, 108 outer product, 116 parallel vectors, 107 perpendicular vectors, 107 unit, 108 vectorization, 6 vibration problem, 380 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99			
biharmonic, 523 bisection method for computing eigenvalues, 453 divide-and-conquer method for computing eigenvalues, 458 eigenvalues, 134 Francis method for computing eigenvalues, 452 has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4 augmented matrix, 27 Tacoma Narrows Bridge, 79 collapse, 380 tensor product, 116, 176 thermal diffusivity, 245 Toeplitz matrix, 203, 513 trace, 5 transient solution, 91 transpose of a matrix, 16 triangle inequality, 111, 120, 126 triangle wave, 258 tridiagonal matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truns problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99		*	V
453 divide-and-conquer method for computing eigenvalues, 458 eigenvalues, 458 eigenvalues, 134 Francis method for computing eigenvalues, 452 has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4 augmented matrix, 27 Tacoma Narrows Bridge, 79 collapse, 380 tensor product, 116, 176 thermal diffusivity, 245 Toeplitz matrix, 203, 513 trace, 5 transient solution, 91 transpose of a matrix, 16 triangle inequality, 111, 120, 126 triangle wave, 258 tridiagonal matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truns problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 augmented matrix, 27		· · · · · · · · · · · · · · · · · · ·	
divide-and-conquer method for computing eigenvalues, 458 eigenvalues, 134 Francis method for computing eigenvalues, 459 has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 Tacoma Narrows Bridge, 79 column, 7 cross product, 115 norm, 119 of constants, 4 operations, 103 orthogonal vectors, 107, 281 orthonormal set of, 108 outer product, 116 transpose of a matrix, 16 triangle inequality, 111, 120, 126 triangle wave, 258 tridiagonal matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 trace, 5 transient solution, 91 transpose of a matrix, 20 transpose of a matrix, 20 triangle inequality, 111, 120, 126 triangle wave, 258 tridiagonal matrix, 203, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truncation, 148,		vector of unknowns, 4	
divide-and-conquer method for computing eigenvalues, 458 eigenvalues, 134 Francis method for computing eigenvalues, 452 has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 440 reduction to a tridiagonal matrix, 449 skew, 432 system of linear equations, 4, 25, 29 sa a matrix equation, 4 augmented matrix, 27 Tacoma Narrows Bridge, 79 collapse, 380 tensor product, 116, 176 thermal diffusivity, 245 Toeplitz matrix, 203, 513 trace, 5 Toeplitz matrix, 203, 513 orthogonal vectors, 107, 281 orthonormal set of, 108 outer product, 116 transpose of a matrix, 16 triangle inequality, 111, 120, 126 triangle wave, 258 tridiagonal matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 37 two's-complement, 145 W W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 spolynomial, 187 as a matrix equation, 4 augmented matrix, 27 unit 108 weighted least-squares, 343 well-conditioned problem, 187 wilkinson bidiagonal matrix, 201, 434 shift, 451 test matrices, 99			
eigenvalues, 458 eigenvalues, 134 Francis method for computing eigenvalues, 452 has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 Tacoma Narrows Bridge, 79 collapse, 380 tensor product, 116, 176 thermal diffusivity, 245 operations, 103 orthogonal vectors, 107, 281 orthonormal set of, 108 outer product, 116 parallel vectors, 107 perpendicular vectors, 107 unit, 108 vectorization, 6 vibration problem, 380 Wilkinson bidiagonal matrix, 201, 434 shift, 451 augmented matrix, 27 unit test matrices, 99	1 1 0	T	
Francis method for computing eigenvalues, 452 has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, sew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 was a matrix equation, 4 augmented matrix, 27 collapse, 380 tensor product, 116, 176 thermal diffusivity, 245 Toeplitz matrix, 203, 513 trace, 5 transient solution, 91 transpose of a matrix, 16 transpose of a matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson Wilkinson U underdetermined system, 249, 321, 338 underflow, 148 unit worthogonal vectors, 107, 281 orthogonal vectors, 107, 281 orthogonal vectors, 107 vectorization, 6 vibration problem, 380 W Weighted least-squares, 343 well-conditioned problem, 187 Wilkinson Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99	E .		
has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 was a matrix equation, 4 augmented matrix, 27 wens of unknowns, 4 operations, 103 orthogonal vectors, 107, 281 orthonormal set of, 108 outer product, 116 parallel vectors, 107 perpendicular vectors, 107 unit, 108 vectorization, 6 vibration problem, 380 Wilkinson bidiagonal matrix, 201, 434 shift, 451 eaugmented matrix, 27		E 1	
has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 winderdetermined system, 249, 321, 338 underflow, 148 unit thermal diffusivity, 245 Toeplitz matrix, 203, 513 trace, 5 transient solution, 91 outer product, 116 parallel vectors, 107 perpendicular vectors, 107 unit, 108 vectorization, 6 vibration problem, 380 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 shift, 451 test matrices, 99	1 0 0	* '	
has n linearly independent eigenvalues, 83 has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 wilkinson 21 × 21 matrix, 452 system of linear equation, 4 augmented matrix, 27 Toeplitz matrix, 203, 513 trace, 5 transient solution, 91 transpose of a matrix, 16 triangle inequality, 111, 120, 126 triangle wave, 258 tridiagonal matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99		* · · · · · ·	
has real eigenvalues, 134 Hilbert, 201 indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 wrate, 5 transient solution, 91 transpose of a matrix, 16 triangle inequality, 111, 120, 126 triangle wave, 258 tridiagonal matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99	, ,	• .	
Indefinite, 268 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 transient solution, 91 transpose of a matrix, 16 triangle inequality, 111, 120, 126 triangle wave, 258 tridiagonal matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 system, 249, 321, 338 underflow, 148 unit transpose of a matrix, 16 parallel vectors, 107 perpendicular vectors, 107 unit, 108 vectorization, 6 vibration problem, 380 V Weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 spolynomial, 187 shift, 451 test matrices, 99	•	1	
transpose of a matrix, 16 Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 transpose of a matrix, 16 triangle inequality, 111, 120, 126 triangle wave, 258 tridiagonal matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99			· · · · · · · · · · · · · · · · · · ·
Jacobi method for computing eigenvalues, 440 Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 triangle inequality, 111, 120, 126 triangle wave, 258 tridiagonal matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99			
Lanczos decomposition of, 516 listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 triangle wave, 258 tridiagonal matrix, 20, 44, 236, 247, 263 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99	1 0 0		•
listing of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 unit veltonization, 6 vibration problem, 380 veltonization, 6 vibration, 6 vibration, 9 vibration problem, 380 veltonization, 6 vibration, 9 vibration problem, 380 Wilkinson problem, 380 Vectorization, 6 vibration problem, 380 Veltonization, 6 vibration problem, 380 Veltonization, 6 vibration, 9 vibration problem, 380 Vectorization, 6 vibration problem, 380 Vectorization, 148 vellanding all problem, 187 veron, 145 underlong all problem, 187 veron, 145 unit problem, 187 veron, 145 ver			
risting of important properties, 440 Poisson, 478 positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 trivial solution, 15 truncation, 148, 151 error, 145 truss problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99		6	vectorization, 6
positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 truncation, 148, 151 error, 145 truss problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 truncation, 148, 151 error, 145 truns problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 wilkinson bidiagonal matrix, 201, 434 shift, 451 test matrices, 99			
Positive definite, 267 QR method for computing eigenvalues, 446 reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 System of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 error, 145 truss problem, 37 two's-complement, 145 W weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 shift, 451 truss problem, 37 two's-complement, 145 underdetermined system, 249, 321, 338 underflow, 148 unit test matrices, 99		truncation, 148, 151	1
reduction to a tridiagonal matrix, 449 skew, 432 spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 unit utruss problem, 37 two's-complement, 145 weighted least-squares, 343 well-conditioned problem, 187 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99	•		NA/
skew, 432 two's-complement, 145 well-conditioned problem, 187 well-conditioned problem, 187 wilkinson 21 × 21 matrix, 452 U wilkinson 21 × 21 matrix, 452 underdetermined system, 249, 321, 338 polynomial, 187 as a matrix equation, 4 underflow, 148 shift, 451 augmented matrix, 27 unit test matrices, 99	1 0 0	truss problem, 37	
spectral theorem for, 439 Wilkinson 21 × 21 matrix, 452 System of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 Wilkinson bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99	•		
Wilkinson 21 × 21 matrix, 452 system of linear equations, 4, 25, 29 as a matrix equation, 4 augmented matrix, 27 U bidiagonal matrix, 201, 434 polynomial, 187 shift, 451 test matrices, 99		•	1
system of linear equations, 4, 25, 29 underdetermined system, 249, 321, 338 polynomial, 187 as a matrix equation, 4 underflow, 148 shift, 451 augmented matrix, 27 unit test matrices, 99		11	
as a matrix equation, 4 underflow, 148 shift, 451 augmented matrix, 27 unit test matrices, 99		_	
augmented matrix, 27 unit test matrices, 99		•	* *
	* · · ·	•	
coefficient matrix, 27 spinere, 307 withinson, J. H., 99, 237			· · · · · · · · · · · · · · · · · · ·
	coefficient matrix, 27	spilete, 307	wiikiiisuli, J. П., УУ, 23/