

INDEX

- ($A^T A$) invertible and A nonsingular
- (best) least-squares solution
- ($m \times n$) linear system
- ($m \times n$) matrix
- "is defined to be"
- A nonsingular and ($A^T A$) invertible
- addition of matrices
- algebraic multiplicity
- angles between vectors
- augmented matrix
- bad vs good equivalences
- basis
- basis and linear independence
- basis and rank
- basis and spanning
- basis for null space
- basis for span
- best approximation
- best approximation is projection
- bivariate data
- Cauchy-Schwarz inequality
- characteristic polynomial $c_A(t)$
- characteristic polynomials and eigenvalues
- characteristic polynomials for similar matrices
- closed form for powers of matrices
- coefficient matrix
- column n -vector
- column space (of matrix)
- commuting and symmetric matrices
- component
- component in direction of vector
- consistency and rank
- consistent linear system
- coplanar
- cross product
- cross product direction
- cross product not commuting
- cross product properties
- cube C_n
- \det = determinant
- \det and inverse
- \det and rank
- \det properties
- diagonal matrices commute
- Corollary 6.53, p. 489
- Definition 6.47, p. 477
- Definition 2.4 and (2.5), p. 79
- Definition 1.1, p. 16
- Introduction, p. 9
- Corollary 6.53, p. 489
- Definition 1.3, p. 18
- Definition 8.30, p. 719
- (APP4.2) or (APP4.3), p. 777
- Definitions 2.14, p. 96
- Theorem 4.58, pp. 341--347
- Definition 4.30, p. 286
- 4.53 and Theorem 4.56, pp. 329, pp. 332--333
- Theorem 4.56, pp. 332--333
- 4.51 and Theorem 4.56, pp. 326, 332--333
- 4.33, pp. 291--293
- 4.35, pp. 297--298
- Terminology 6.15, p. 413
- Theorem 6.14, p. 412
- 6.60, pp. 509--510
- 6.26, p. 428
- Definition 8.7, p. 656
- Theorem 8.8, p. 656
- Proposition 8.28, p. 713
- pp. 639 and 643
- Definitions 2.14, p. 96
- Definitions 1.8, p. 23
- p. 261
- Proposition 3.14, p. 142
- Definitions 1.17, p. 35
- Definition 6.19, p. 418
- 3.28, p. 166
- Definition 2.8, p. 81
- Definition 6.78, p. 542
- Definition 6.69, p. 530
- p. 553
- Proposition 6.71, p. 533
- Theorem 6.81, p. 545
- 5.1, p. 356
- Definition 5.5, pp. 366-367 and Proposition 5.7, p. 371
- Theorem 5.12, p. 378
- Proposition 5.13, pp. 381--382
- 5.10, pp. 373--375
- Proposition 3.13, pp. 140--141

- diagonal matrix
- diagonal matrix terminology
- diagonal of square matrix
- diagonalizability
- diagonalizable (matrix)
- diagonalizable and distinct eigenvalues
- diagonalizable and symmetric matrices
- diagonalization
- diagonalized matrix powers
- diagonalizing: how to
- difference equations
- dim = dimension (of vector space)
- dim of null space and dim of range space
- dim of range space and dim of null space
- dim(range space) and rank
- dim(span) and rank
- directed line segment
- distinct eigenvalues implies diagonalizable
- distributive law
- dot product
- dot product and transpose
- dot product properties
- E Pluribus Unum
- echelon form
- effects of elementary operations on det
- eigenspace
- eigenspace and null space
- eigenvalue
- eigenvalues and characteristic polynomials
- eigenvector
- eigenvectors and exponentials of matrices
- eigenvectors and powers of matrices
- elementary matrices
- elementary operations
- equilibrium
- equivalent linear systems
- Euler's formula
- exponential of matrix
- exponential of matrix and eigenvectors
- Fibonacci numbers as difference equation
- Fibonacci numbers defined
- Fibonacci numbers population model
- Fibonacci numbers, closed form
- fixed point
- fixed points and Markov matrices
- foxes and rabbits
- foxes and rabbits
- Definition 3.3, p. 134
- Terminology 8.18, p. 687
- Definition 3.1, p. 133
- Theorem 8.32, pp. 721--722
- Definition 8.23, p. 693
- Theorem 8.34, p. 727
- Theorem 8.34, p. 727
- Definition 8.23, pp. 693--694
- Theorem 8.19, pp. 687--688
- 8.25 pp. 696--697
- Definition 1.24, pp. 50--51
- Definition 4.39, p. 307
- Corollary 4.50, p. 320
- Corollary 4.50, p. 320
- Corollary 4.43, p. 313
- Theorem 4.41, p. 310
- Definitions 1.20, pp. 38--39
- Theorem 8.34, p. 727
- pp. 769--770
- Definitions 6.6 and 6.8, pp. 403--404
- Proposition 6.48, p. 479
- 6.12, pp. 408--409
- Introduction, p. 3
- Definition 2.20, p. 104
- 5.8, p. 372
- Definition 8.3, p. 650
- Theorem 8.5, p. 652
- Definition 8.1, p. 647
- Theorem 8.8, p. 656
- Definition 8.1, p. 647
- Remarks APP2.7, p. 764
- Theorem 8.14, p. 666
- Definitions 3.52, pp. 224--227
- Definition 2.24, p. 109
- Definition 8.10, p. 659
- Definition 2.11, p. 90
- p. 750
- pp. 759--760
- Remark APP2.7, p. 764
- pp. 635--636
- Definition 7.25, pp. 632--634
- Example 7.24, pp. 629--632
- Example 8.17, pp. 676--682
- Definition 8.10, p. 659
- Theorem 8.11 and Remarks 8.13, pp. 661 and 664--665
- Examples 1.25(4), pp. 57--63
- Introduction, pp. 4--7

- foxes and rabbits solved
- foxes and rabbits, matrix construction
- free variables
- free variables and number of solutions
- free variables intuition, corrected
- free variables intuition, false
- function
- Gauss-Jordan elimination
- geometric multiplicity
- global method for solving difference equations
- golden ratio
- golden rectangle
- good vs bad equivalences
- Gram-Schmidt
- History
- homogeneous linear system
- homogeneous nontrivial solutions
- how to diagonalize
- hypotenuse of right triangle
- I
- identity matrix
- identity matrix properties
- inconsistent linear system
- initial point
- initial state of difference equation
- inner product
- inverse (of a matrix)
- inverse and det
- inverse and linear systems
- inverse calculation
- invertible (matrix)
- least-squares approximating line
- least-squares approximating model
- least-squares approximation
- least-squares error
- least-squares solutions and normal equations
- least-squares solutions when A nonsingular
- legs of right triangle
- length (of vector)
- line
- linear combinations
- linear combinations and linear systems
- linear combinations and rank
- linear dependence and nontrivial linear combination
- linear dependence and rank
- linear dependence and unnecessary vectors
- Examples 8.37 and 8.38, pp. 729--746
- Examples 7.22(b), pp. 616--619
- Definitions 2.13, p. 93
- p. 152
- 3.28, p. 166
- Intuition 3.23, pp. 156--159
- Definition 7.1, p. 561
- 2.29, p. 112
- Definition 8.30, p. 718
- 8.20, p. 689
- pp. 683--684
- pp. 683--684
- Theorem 4.58, pp. 341--347
- 6.44, p. 465
- Introduction, pp. 2--3
- Definitions 3.16 and (3.17), p. 146
- p. 152
- 8.25, pp. 696--697
- p. 766
- Definitions 3.5, pp. 135--136
- Definitions 3.5, pp. 135--136
- Proposition 3.6, p. 136
- Definition 2.8, p. 81
- Definitions 1.20, pp. 38--39
- p. 70
- Definitions 6.6 and 6.8, pp. 403--404
- Definitions 3.45, p. 210
- Theorem 5.12, p. 378
- Theorem 3.47, p. 215
- 3.49, p. 218
- Definitions 3.45, p. 210
- Definition 6.61 and Theorem 6.63, pp. 511 and 515
- Theorem 6.65, pp. 521--522
- Terminology 6.15, p. 413
- Definition 6.58, pp. 496--497
- Theorem 6.55, pp. 490--491
- Corollary 6.56, p. 494
- p. 766
- Definition 6.1, Remarks 6.3, pp. 393--395
- Definition 6.84
- Definition 4.1, pp. 231--232
- Theorem 4.4, p. 242
- Theorem 4.4, p. 242
- Proposition 4.23, p. 270
- Theorem 4.21, p. 267
- Theorem 4.28, p. 284

linear equation	Definition 2.1, p. 77
linear independence and basis	4.53 and Theorem 4.56, pp. 329, pp. 332--333
linear system	Definition 2.2, p. 78
linear systems and inverse	Theorem 3.47, p. 215
linear systems and linear combinations	Theorem 4.4, p. 242
linear systems and row equivalences	Theorem 2.27, p. 111
linear transformation	Definition 7.3, p. 566
linear transformations and matrices	Theorem 7.8, p. 572
linearly dependent	Definition 4.19, p. 266
linearly dependent columns and singularity	Theorem 4.25, p. 272
linearly independent	Definition 4.19, p. 266
local method for solving difference equations	8.15, pp. 667--668
magnification factor	5.1, p. 360
magnitude (of vector)	Definition 6.1, Remarks 6.3, pp. 393--395
Markov matrices and fixed points	Theorem 8.11 and Remarks 8.13, pp. 661 and 664--665
Markov matrix and process	Definitions 1.26, p. 68
matrices and linear transformations	Theorem 7.8, p. 572
matrix	Definition 1.1, p. 15
matrix addition	Definition 1.3, p. 18
matrix form of linear system	Definitions 2.14 and (2.15), pp. 94--95
matrix form, homogeneous linear system	Definitions 3.16 and (3.17), p. 146
matrix multiplication	Definitions 1.10 and 1.12, pp. 24, 26, and 27
matrix operations properties	1.15, pp. 31--32
matrix that is not diagonalizable	Example 8.29, pp. 715--716
matrix times standard basis	Lemma 7.10, p. 574
Moonorgs	Examples 1.25(5), pp. 63--67
Moonorgs, matrix construction	Examples 7.22, pp. 619--623
multiplication of matrices	Definitions 1.10 and 1.12, pp. 24, 26, and 27
multiplicity, algebraic	Definition 8.30, p. 719
multiplicity, geometric	Definition 8.30, p. 718
natural numbers	Introduction, p. 10
nontrivial linear combinations and linear dependence	Proposition 4.23, p. 270
nontrivial solutions	3.33, p. 183
norm (of vector)	Definition 6.1, Remarks 6.3, pp. 393--395
normal equations	6.54, p. 490
normal equations and least-squares solutions	Theorem 6.55, pp. 490--491
not diagonalizable	Example 8.29, pp. 715--716
null space	Definition 3.35, p. 188
null space and eigenspace	Theorem 8.5, p. 652
null space basis	4.33, pp. 291--293
null space of $(A^T A)$	Corollary 6.52, p. 488
nullity and rank	Theorem 4.46, p. 317
nullity (of a matrix)	Definition 4.44, p. 314
nullity and number of free variables	Theorem 4.45, p. 315
number of free variables and nullity	Theorem 4.45, p. 315

number of free variables and rank	3.28, p. 166
number of solutions and free variables	p. 152
number of solutions illustrated	Remark 2.10, p. 90
number of solutions of linear system	Theorem 3.20, pp. 150--153
number of vectors in bases	Theorem 4.37, p. 306
n-vector	Definitions 1.17, p. 34
order of square matrix	5.1, p. 354
orthogonal	Definition 6.10, p. 406
orthogonal advantage (1): Pythagorean	6.33, p. 441
orthogonal advantage (2): linear combinations	6.36, p. 447
orthogonal advantage (3): projections	6.40, p. 456
orthogonal bases of eigenvectors and symmetry	Remark 8.36, p. 729
orthogonal basis	Definition 6.32, p. 439
orthogonal complement	Definition 6.49, pp. 479--480
orthogonal complement properties	Theorem 6.51, p. 483--484
orthogonal implies independence	Theorem 6.31, p. 436
orthogonal projection	Definition 6.13, pp. 410--411
orthogonal set	Definition 6.29, p. 434
orthogonal terminology	Terminology 6.5, p. 400
orthonormal set	Definition 6.43, p. 462
parallel (vectors)	Definitions 6.22, pp. 423--424
parallelepiped	Definition 6.75 and Proposition 6.76, pp. 539--541
parallelogram formed by two vectors	5.1, p. 357
pasting of matrices	Terminology 1.6, pp. 21--23
picture of vector operations	p. 45
point in opposite direction	Definitions 6.22, pp. 423--424
point in same direction	Definitions 6.22, pp. 423--424
popular vector spaces	4.17, pp. 260--261
powers of diagonalized matrix	Theorem 8.19, pp. 687--688
powers of matrices and eigenvectors	Theorem 8.14, p. 666
powers of matrices, closed form	pp. 639 and 643
powers of square matrix	Definitions 1.28, p. 71
prerequisites	Introduction, p. 8
projection	Definition 6.13, pp. 410--411
projection is best approximation	Theorem 6.14, p. 412
projection onto vector	(6.17) and Definition 6.16, pp. 415--416
projection onto vector formula	Theorem 6.18, p. 418
Pythagorean theorem	pp. 765--769
\mathbb{R}^n	Definitions 1.17, p. 35
rabbits and foxes	Examples 1.25(4), pp. 57--63
rabbits and foxes	Introduction, pp. 4--7
rabbits and foxes solved	Examples 8.37 and 8.38, pp. 729--746
rabbits and foxes, matrix construction	Examples 7.22(b), pp. 616--619
radians	p. 749
range space	Definitions 3.41 and (3.42) and (3.43), pp. 199-203
range space and span	Theorem 4.15, p. 258

rank (of a matrix)	Definition 3.26, pp. 162--163
rank and basis	Theorem 4.56, pp. 332--333
rank and consistency	3.28, p. 166
rank and det	Proposition 5.13, pp. 381--382
rank and dim(range space)	Corollary 4.43, p. 313
rank and dim(span)	Theorem 4.41, p. 310
rank and linear combinations	Theorem 4.4, p. 242
rank and linear dependence	Theorem 4.21, p. 267
rank and nullity	Theorem 4.46, p. 317
rank and number of free variables	3.28, p. 166
rank and singularity	Theorem 4.25, p. 272
rank and unique solutions	Theorem 3.39, p. 194
rank properties	3.30, p. 173
real numbers	Introduction, p. 11
reduced echelon form	Definition 2.22, p. 107
reflection	7.16 and 7.17, pp. 605--607
representation of vector by directed line segment	Definitions 1.20, p. 40
right-hand rule	pp. 552--553
rotation matrices	p. 752
row equivalence and linear systems	Theorem 2.27, p. 111
row equivalent (matrix)	Definition 2.26, p. 110
row n-vector	Definitions 1.8, p. 23
row space (of matrix)	p. 261
scalar multiplication of matrices	Definition 1.3, p. 18
scalar product	Definitions 6.6 and 6.8, pp. 403--404
scalar triple product	Definition 6.72 and Proposition 6.74, pp. 534 and 537
scalars	Introduction, p. 12
similar matrices	Definition 8.22, p. 693
similarity and characteristic polynomials	Proposition 8.28, p. 713
simple eigenvalue	Chapter VIII homework
singular (matrix)	Definition 3.38, p. 193
singular matrix and unique solutions	Theorem 3.39, p. 194
singularity and linearly dependent columns	Theorem 4.25, p. 272
singularity and rank	Theorem 4.25, p. 272
solution of linear system	Definition 2.6, p. 80
solution of systems of constant-coefficient differential equations	Theorem APP2.3 and Corollary APP2.5, pp. 759--760
solutions in terms of homogeneous solutions	Theorem 3.18, p. 148
solutions of difference equations	Theorem 1.29, p. 72
span	Definitions 4.11, pp. 251--252
span and range space	Theorem 4.15, p. 258
span basis	4.35, pp. 297--298
spanning and basis	4.51 and Theorem 4.56, pp. 326, 332--333
square corner	p. 390
square matrix	Definitions 1.28, p. 71
stable point	Definition 8.10, p. 659
standard basis	Definition 4.32, pp. 288--289

- standard matrix
- standard matrix for 45 degree rotation
- standard matrix for 90 degree rotation
- standard matrix for projection
- standard matrix for reflection
- standard matrix for rotation
- steady state
- submatrix
- subspaces of \mathbb{R}^2
- sum of angles
- symmetric implies diagonalizable
- symmetric matrices and commuting
- symmetric matrix
- symmetry and orthogonal bases of eigenvectors
- systems of constant-coefficient differential equations
- terminal point
- too many vectors implies linear dependence
- transpose (of a matrix)
- transpose and dot product
- transpose properties
- triangle inequality
- trivial solution
- trivial vector
- unique solutions
- unique solutions and rank
- unique solutions and singular matrix
- unit circle
- unit vector
- unnecessary vectors and linear dependence
- vector form of linear system
- vector operations picture
- vector space
- vector spaces, popular
- vector subspace
- weighing self
- zero vector
- Definition 7.6, p. 570
- 7.12, pp. 587--593
- Examples 7.11(2), p. 578
- 7.13 and (7.14), pp. 595--597
- Proposition 7.18, p. 607
- p. 752
- Definition 8.10, p. 659
- Definitions 5.3, p. 364
- Proposition 4.10, p. 250
- APP1.1, p. 750
- Theorem 8.34, p. 727
- Proposition 3.14, p. 142
- Definition 3.10, p. 139
- Remark 8.36, p. 729
- (APP2.1) and (APP2.2), pp. 756--758
- Definitions 1.20, pp. 38--39
- Corollary 4.27, p. 281
- Definition 3.7, p. 137
- Proposition 6.48, p. 479
- 3.9, p. 138
- 6.28, p. 431
- Definitions 3.16, p. 147
- Definitions 3.16, p. 147
- 3.33, p. 183
- Theorem 3.39, p. 194
- Theorem 3.39, p. 194
- p. 749
- Definition 6.4, p. 396
- Theorem 4.28, p. 284
- Definitions 2.14 and (2.16), p. 96
- p. 45
- Definition 4.8, p. 248
- 4.17, pp. 260--261
- Definition 4.8, p. 248
- Examples 6.59(c), pp. 502--505
- Definitions 3.16, p. 147