A	Autocorrelation 176, 615-616
Abel's function 256	Axiom of Choice 164-165
Absolutely integrable 66, 182	В
Absolutely summable Signal 65	Balian-Low theorem 771-787
Accumulator 177	frames 784
Adjoint	orthonormal basis 773-776
frame operator 220	Banach space 147-148, 198
Hilbert operator 210	construction 201-205
Admissibility condition 805	completion 203-205
Algebra 80	Bandlimited 538
σ– (sigma-) 80, 227	Bandpass filter 465, 599-601
Algebraic signals 25	Bandwidth, 3-db 464
Almost everywhere 231	Basis 154, 163
Ambiguity function 769	orthonormal 211-215
Amplitude 51	of translates 840
modulation (AM) 52, 469	Bat 645
spectrum 463	Bayes 82
Analog	classifier 346
convolution 176-177	decision rule 348
filter 650	theorem 82, 91
Gaussian 29	Bell, A. 93
signal 1, 21-22	Bessel 612
signal edge 334	function 475, 611-612
sinusoid 51	inequality 156-157
system 174	Biased estimator 616
Analog-to-digital converter (ADC) 41	Bilinear transformation 638
Analytic 71	Binomial distribution 87
signal 692	biological and computer vision 900
Analyzing wavelet 805	Borel set 229
Angle modulation 471	Boundary curvature 368
Antisymmetric 63	Bounded 65, 182
Approximate signal 875-876	linear operator 197
Approximating identity 253-256	B-spline 189, 739
Approximation, ideal filter 624	window 738
Arc 75	Butterfly 68
Associated filter, multiresolution	Butterworth, S. 654
analysis 852	filter 654-655
Atomic force microscope (AFM) 336	11101 034-033
Attneave 24	C
Australia 887	C ⁺ , extended complex plane 555, 626

Signal Analysis: Time, Frequency, Scale, and Structure, by Ronald L. Allen and Duncan W. Mills ISBN: 0-471-23441-9 Copyright © 2004 by Institute of Electrical and Electronics Engineers, Inc.

C++ 507-508	Compression 894
Canny edge detector 335-336	Concavity 37, 354
Canonical linear map, multiresolution	Conditional probability 81
analysis 856	Congruential generator 591
Cantor, G. 163	linear 591
Cardano, G. 81	Conjugate
Cardinality 163	exponents 143-144
Carleson's theorem 529	mirror filter 699
Carrier frequency 52	Contextual analysis 61
Cat 24, 69	Continuous
Cauchy	mean 89
integral 76-77	operator 197
principal value 689	random variable 88
residue 78	variance 90
sequence 148, 198	wavelet transform 803
Cauchy-Riemann equations 73	Contour 75
Cauchy-Schwarz inequality 146, 151	integral 76, 566
Cauer, W. 676	Convolution 115, 176
Cauer filter 676-680. See also elliptic filter	discrete 498
Causal 627	of distributions 250-252
system 122, 183	properties 131-132, 184-185
Cepstral coefficient 345	theorem 129, 182, 428, 460
Chain rule 72	Co-occurence matrix 305-307
Charge-coupled device (CCD)	texture descriptors 307
897	Countable 163
Chebyshev, P. 664	Covering, open 230
Chebyshev	Cross Wigner-Ville distribution 764
polynomial 664-665	Cross-correlation 114, 176
Type I filter 664	Cross-terms (interference-) 761, 769-770
Type II filter 670	Cubic spline 46-50, 839, 851, 862
Chemical mechanical planarization (CMP) 618	Curvature 354
Chirp	Curve 75
detection 643	Cut-off frequency 625
linear 730-732	
Chirp z-transform (CZT) 573, 687	D
algorithm 574-575	DC (direct current) 405
City block metric 142	waveform 442
Classification 283-284, 346	Delay 605, 669
Closed set 65, 148	group 606-608
Closing 326	phase 605
Cohen, L. 789	Delta, see also Dirac
Cohen class transform 771, 789	analog 179
Comfort noise 79	discrete 39
Compact 65	Dense 154
support 65, 190	Density Function 85
Complete 154, 158	Wigner-Ville 766
Complete elliptic integral 677-678	Derivative 71, 241, 332
Completion 203	of Gaussian operator 330
Complex	Descartes, R. 140
integration 75-78	Detail signal 879-880
Lebesgue measure 230-231	Deterministic signal 78
numbers (C) 70	Difference equation 130, 571-572,
-valued signal 22, 35	627-628
Component (channel) signal 9	Difference of boxes (DOB) filter 329

Differentiable 71	Dual-tone multi-frequency (DTMF) 281-282
Digital	588-604
signal 1, 35	table of pairs 590
signal processor (DSP) 7, 507, 509	table of pairs 390
Dilation 323-325, 803	
Dirac, P. 33	E
Dirac Dirac	Echo canceller 133-136, 908-909
comb 452-454	Echolocation 645
delta 33-35, 241, 247-249, 443	Edge
delta, properties 186-188	analog and discrete 334
1	detection 326-338, 905-908
Direct current (DC) 405, 442 Direct	Canny 336
form I 630	maximal response 336
form II 631	Eigenfunction 534-535
	Eigenvector 534
sum 160	Electrocardiogram (ECG, EKG) 12-16,
Dirichlet, P. 392, 526	907-908
Dirichlet kernel 392, 526	Electroencephalogram (EEG) 8-9, 643
Discrete	Elliptic
algebraic signal 37	filter 676-685
convolution 498-499	integral 677
cosine transform (DCT) 894	complete 677-678
delta (impulse) 39	sine 678-680
density function 86	Endpoint detection 330, 344, 649
Fourier series (DFS) 495-497	Engine knock detection 344-345
Fourier transform (DFT) 155-156,	Enhancement 314
482-484	wavelet-based 897
inverse (IDFT) 485-487	Envelope 692
properties 497-501	detection 693
mean 88	Equiripple condition 664-665, 670
random variable (RV) 85-86	Equivalence
rational function 37	class 202
signal 1, 35	relation 202
edge 334	Equivalent distributions 243
frequency 51, 55-56	Erosion 325-326
sinusoid 38	Estimator 616
system 109, 111	Even and Odd Signals 59
unit step 40	Even 63-64
variance 88	Event 81
Discrete-time Fourier transform (DTFT)	Exact frame 218
510-515, 555	Expectation 88-89
existence 514-515	Exponential
inverse (IDTFT) 517-519	distribution 89
for <i>l</i> ^p 528	signal 26, 38, 212, 448
and linear, translation-invariant systems 534	anti-causal 557
properties 529-534	causal 556
Discriminant function 350-351	Extended complex plane (C ⁺) 555
Distribution 84, 241-253	Extended complex plane (C) 333
defined 242	
equivalent 243	F
as limit 252	Fast Fourier transform (FFT) 2, 501
properties 244-246	decimation-in-frequency 505-507
Dog 308	decimation-in-time 502-505
Dolphin 52	implementation 507-510
Doppler 53	Fatou, P. 237

Fatou's lemma 237-238	conoralized see Conoralized Fourier
Feature extraction 342-346	generalized, see Generalized Fourier transform
	Hertz 405
Feature 279	inverse (IFT) 408
Feller, W. 81	for L ² (R) 424-429
Fermat, P. 140	
Filter 314-322, 460, 462-463.	normalized 405
analog 651	properties 411-421
approximation 624-626	properties table 421
bank 589, 601-604	radial 404
exact reconstruction 697	short-time, see Short-time Fourier transform
perfect reconstruction 694-695	table 407
Butterworth 654	windowed, see Short-time Fourier transform
Cauer (elliptic) 676	Fractal 69
Chebyshev type I 664	Frame 216-225, 777
Chebyshev type II (inverse) 670	bounds 218, 821
design	dual 222, 782
analog 650-685	exact 821
bilinear transformation 638	operator 219-223, 782
discrete 620-643	adjoint 220, 782
impulse invariance 633	tight 821
Laplace transform 636-638	wavelet 821-832
low-pass 632-639, 652	windowed Fourier 756-759
sampling analog 633-636	Frequency 38, 51
window 623-624	domain 20, 56
elliptic (Cauer) 676	signal analysis 585
frequency transformations 639-640	estimation 608
ideal 465-466, 621	instantaneous 473-474
inverse Chebyshev 670	modulation (FM) 52
low-pass 621-622, 653	response 535, 604-605
median 322	transformations (filter) 639-640
morphological 322	Fubini, G. 240
nonlinear 321-326	Fubini's theorem 240
optimal 316, 685	Functional 241
quadrature mirror (QMF) 699	Fundamental period 51
wavelet-based 895	
Finite energy 66, 138	G
Finite impulse response (FIR) 629, 641-642	Gabor, D. 30, 717
Finitely supported 64	problem 759
Finitely supported signals 60	Gabor
Fischer, E. 166	elementary function 30-31, 718-722, 903
Formant 54, 757	transform (GT) 713-735, 903-904
formants 50	adaptive 720
Fourier, J. 384	inverse (IGT) 723-725, 729
Fourier	properties 735
series (FS) 2, 166, 385-387	Galileo Galilei 58
convergence 391, 394	Gauss, K. 29, 501
partial 388	Gaussian 29, 39, 353, 361, 367, 416, 467-468,
properties 389	652, 737, 815-817, 819
trigonometric 397-399	filtering 695-696
transform (FT) 403	smoothing 357
discrete, see Discrete Fourier transform	Generalized Fourier transform 440-443
discrete-time, see Discrete-time Fourier	inverse 443
transform	properties 444-451
existence 409	Geothermal gradient 17-18

Gestalt psychology 301 Gibbs, J. 394, 523 Gibbs phenomenon 186, 394, 523-528 Gram-Schmidt orthogonalization 162 Grisey, G. 713	discrete Fourier transform (IDFT) 485-487 discrete-time Fourier transform (IDTFT) 517-519 Fourier transform (IFT) 408 Gabor transform (IGT) 729
Group delay 606	short-time (windowed) Fourier transform 741 wavelet transform (IWT) 810
H	Isometry 210, 429-431
Haar, A. 213	Isomorphism 210
Haar basis 213-215, 837	
Hamming distance classifier 346	J
Hartmann, N. 22	Jacobi, C. 677
Heat diffusion equation 28, 365	Jacobi elliptic sine 677
Heine-Borel theorem 65, 190	Joint
Heisenberg, W. 743	density 90, 613
Heisenberg uncertainty principle 743	normal 90
Hertz, H. 51, 93	distribution function 613
Hidden Markov model (HMM) 873, 917	Julesz's thesis 306-307
High-definition television (HDTV) 3	
Hilbert, D. 150, 688	K
Hilbert	Khinchin, A. 615
adjoint operator 210	Knot 45
space 150, 158-168	Kolmogorov, A. 81
separable 164, 206-210	Kotelnikov, V. 94
two-dimensional 726-727	Kronecker, L. 385
transform 688	Kronecker delta 385
associated analytic signal 692	
discrete 690	L
properties 689-691	l ¹ 65
Histogram 289-292	L ¹ 66
Hölder inequality 145, 191	l^2 66
Hubble 54	L ¹ 66
T	<i>I</i> ^p 137 <i>I</i> ∞ 127
I	l^{∞} 137
Ideal filter 465-466, 621	L^{p} 191, 193, 205, 239 L^{∞} 191
Image 10, 726, 894	
Impulse	Labeling 279
invariance 633	Lagrange, J. 45
response 128, 181, 605	Lagrange interpolation 45-46
finite (FIR) 629 infinite (IIR) 133, 629	1
Independent event 82	multipliers 316
Infinite impulse response (IIR) 133, 629	Laplace, P. 27 Laplace
Inner product 205	identity 27
space 149-153, 205-206	transform 636
Instantaneous	properties 637
frequency 52, 473-474, 692	Laplacian pyramid 695-697, 891-892
phase 692	Laurent series 72, 557-558
radial frequency 692	Lebesgue, H. 260
Interference-term (cross-) 761, 769-770	Lebesgue
Interferometry 618-620	dominated convergence theorem 238
Interpolation 42-50	integral 225, 232-240
Inverse	measurable set 229
Chebyshev filter (Type II) 670	measure 229-230

lim inf 237, 558 lim sup 237, 558	Moving average filter 15, 593-595
Linear	system 178
congruential generator 591	Multichannel 9
interpolation 45	Multidimensional 10
operator 197	Multiresolution analysis (MRA) 835-842, 873
bounded 197-198	associated discrete low-pass filter 852
norm 197	canonical map 856
phase 640	orthonormal wavelet 857
system 177, 459	scaling function 847
translation-invariant (LTI) 128, 178	Multivariate distribution 90
Liouville, J. 628	N
Lipschitz, R. 907	N
Lipschitz regularity 907	Nearest-neighbor clustering 288
Locality	Noise 589
frequency 546	Nonmeasurable set 231-232
time 546	Norm
Localization	inner product 151
random signal 614	operator 197
time-frequency 741, 746, 754	Normalized cross-correlation 338-341
Logon 714	Normed linear space 142-143, 195-198
Loma Prieta earthquake 5-6	Numerical instability 224
Lorentzian 653	nverse Hertz Fourier Transform 466
	Nyquist, H. 2
M	Nyquist
Malvar wavelet 895	density 754
Marconi, G. 93	rate 542
Marginals 767-768	0
Marr, D. 24, 337, 352	
Marr, D. 24, 337, 352 Marr's program 900	Odd 63-64
	Odd 63-64 Open
Marr's program 900 Matched filter 341	Odd 63-64 Open set 65, 148
Marr's program 900	Odd 63-64 Open set 65, 148 covering 230
Marr's program 900 Matched filter 341 Matching pursuit 873, 918	Odd 63-64 Open set 65, 148 covering 230 Opening 326
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820 Minimum distance classifier 346 Minkowski inequality 146, 192	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163 translates theorem 843
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820 Minimum distance classifier 346	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163 translates theorem 843 wavelet 857-861
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820 Minimum distance classifier 346 Minkowski inequality 146, 192 Mixed-domain signal transform 712 Mixed-domain signal analysis 873	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163 translates theorem 843
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820 Minimum distance classifier 346 Minkowski inequality 146, 192 Mixed-domain signal transform 712	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163 translates theorem 843 wavelet 857-861
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820 Minimum distance classifier 346 Minkowski inequality 146, 192 Mixed-domain signal transform 712 Mixed-domain signal analysis 873 Modulation 114, 461, 468-469	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163 translates theorem 843 wavelet 857-861 existence 860
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820 Minimum distance classifier 346 Minkowski inequality 146, 192 Mixed-domain signal transform 712 Mixed-domain signal analysis 873 Modulation 114, 461, 468-469 amplitude 52, 469	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163 translates theorem 843 wavelet 857-861 existence 860 P
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820 Minimum distance classifier 346 Minkowski inequality 146, 192 Mixed-domain signal transform 712 Mixed-domain signal analysis 873 Modulation 114, 461, 468-469 amplitude 52, 469 angle 471-472	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163 translates theorem 843 wavelet 857-861 existence 860 P Parallelogram law 152, 205
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820 Minimum distance classifier 346 Minkowski inequality 146, 192 Mixed-domain signal transform 712 Mixed-domain signal analysis 873 Modulation 114, 461, 468-469 amplitude 52, 469 angle 471-472 frequency 52, 537	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163 translates theorem 843 wavelet 857-861 existence 860 P Parallelogram law 152, 205 Parseval's theorem 428, 500, 533, 565
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820 Minimum distance classifier 346 Minkowski inequality 146, 192 Mixed-domain signal transform 712 Mixed-domain signal analysis 873 Modulation 114, 461, 468-469 amplitude 52, 469 angle 471-472 frequency 52, 537 phase 52	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163 translates theorem 843 wavelet 857-861 existence 860 P Parallelogram law 152, 205 Parseval's theorem 428, 500, 533, 565 Gabor transform 728
Marr's program 900 Matched filter 341 Matching pursuit 873, 918 Mathematics, most important function 73 Maxwell, J. 28, 93 Maxwell's equations 28 Mean 88, 89, 613 Measurable function 227 Measure 226-228 Median Filter 15, 322 Melville, H. 832 Metric space 141-142 Mexican hat 819-820 Minimum distance classifier 346 Minkowski inequality 146, 192 Mixed-domain signal transform 712 Mixed-domain signal analysis 873 Modulation 114, 461, 468-469 amplitude 52, 469 angle 471-472 frequency 52, 537 phase 52 Morphological filter 322-326	Odd 63-64 Open set 65, 148 covering 230 Opening 326 Operator adjoint 210 continuous 197 ordering 210 Optimal filter 316-321, 685 Orthogonal 153 wavelet 857 representation 875 Orthonormal 153 basis 163 translates theorem 843 wavelet 857-861 existence 860 P Parallelogram law 152, 205 Parseval's theorem 428, 500, 533, 565 Gabor transform 728 short-time Fourier transform 740

D 250	5
Pattern 279	Random
detection 338-351	signal 78, 91
structural 342	variable 84, 613
statistical 346-351	Rapidly
recognition 873, 913-917	decreasing 208
Periodic 51	descending 242
Period, fundamental 51	Rational function 25, 37, 653
Periodogram 616, 619	Receptive field (RF) 900-904
improvement 617	Reconstruction from samples 540-541
Phase 51	Region
delay 605	of convergence (ROC) 626
estimation 608	merging 286-288
factor (W _N) 490	splitting 286-288
modulation 52	Registration 279
Phone 60	Remote sensing 10
Phoneme 60, 285, 313, 912	Republic, Plato's 726
classification 83	Residue 78
Piecewise linear function 838, 849	Richter, C. 303
Pixel 10	Richter scale 303
Plancherel's theorem 428	Riemann, G. 225
Gabor transform 727	Riemann
short-time Fourier transform 740	integral 225-226
Planck, M. 22	-Lebesgue lemma 258, 413
Plasma etching 330	Riesz, F. 166
Poisson, SD. 88	Riesz
Poisson distribution 88, 898	basis 841
Polarization identity 206	bound 841
Pole 77, 628	of translates 845
Polynomial signal 24, 37	-Fischer theorem 166-167
Positive operator 210	representation theorem 209
Power	Ripple 625
series 72, 557	Rosenfeld, A. 274
set 163	
spectral density (PSD) 613-614	S
Primary (P) wave 5	σ-algebra 80, 227
Probability 79-81	Sample space 80-81
density function 613	Sampling 40, 116
distribution function 613	frequency 40
measure 80	interval 40
space 81	theorem 538-542
Projection 160-161	Sawtooth signal 33, 400-403
Prony model 345	Scale 67, 354, 803-804
	domain 21
0	space 351-368
QRS complex 13-15	decomposition 360
Quadratic time-frequency transform 760-771	kernel conditions 357
Quadrature mirror filter (QMF) 699, 882	Scaling function 847-852
Quantization error 41	Scanning electron microscope (SEM) 899
Quantization error 41	Schwartz, L. 260
	Schwarz
R	inequality 192
Rademacher, H. 154	space 208-209
Rademacher signal 154	Secondary (S) wave 5
Radius of convergence 559	Segmentation 14, 277-278, 589

Seismic	Symmetry 63
data analysis 909	System function 563, 627
section 804	System remedian 303, 027
Seismogram 5, 643	T
Shannon, C. 2	Taylor, B. 25
Shannon	Taylor series 25-26
function 465	Tempered distribution 243
-Nyquist interpolation 544	Test function 242
Shape 354	Texture 300-314
recognition 883	analysis, mixed-domain 912-913
Sharpness 625	segmentation 301-314
Short-time (windowed) Fourier transform (STFT)	spectral methods 308
736-747	statistical 301
discretized 747-760	structural 314
inverse (ISTFT) 741	Thresholding 117, 119, 176, 288-300
properties 740-741	hard 894
sampling 749	information theoretic 297-298
Sifting property 40	nonparametric 294-297
Signal	parametric 292-294
analysis	soft 896
narrow-band 586-608	Tight frame 218
wide-band 643-650	Time domain 10
envelope 692	signal analysis 273
-to-noise ratio 335	Time-frequency
periodic 51	(Nyquist) density 754
Signum 33, 446	plane 589, 596-601, 751-753
Sinc function 215	transform 712
Sinusoid 25, 38, 213, 587-588	quadratic 760-771 kernel-based 770-771
Slowly increasing 243	Time-scale transform 802
Sobolev, S. 260	Tone 733-735
Spectrum estimation 608, 613-617	detection 587
Speech 60-62, 912	Top surface 324
analysis 646-650	Transfer (system) function 563, 627
endpoint 649	Transient response 669-670
formants 647	Translate of a set 323
pitch 647	Translation-invariant 127, 177
envelope 693-694	Translation invariant 127, 177
segmentation 283	U
voiced and unvoiced 283, 649	Umbra 324
Spline 46-50, 188-190. <i>See also</i> Cubic spline	Unbiased estimator 319
B- 189, 739	Uncertainty principle 545-547, 743-746
natural 49	Uncertainty principle 620, 855
Spline Function 993	Unconditional basis, see Riesz basis
Splintering, QRS complex 15	Uncorrelated 613
Stable 138, 182, 627 Standard deviation 88, 90, 613	Uncountable set 163
Standard deviation 88, 90, 013 Step function 836, 849, 861	Uniform convergence 186
Structural analysis 18-20, 314	Uniformly continuous 194
Structure 751, 904	Unit step 32, 40
Sunspot 57, 493	Unvoiced 61, 283
Surface	V
profilometer 302	Variance 613
wave 5	Vector space 140-141
wave J	100001 space 170-171

Ville, J. 761, 789	Window
Voiced 61, 283	Bartlett 611
Voxel 10	Blackman 611-612
	b-spline 738-740
W	function 609-612, 736-737
Wavelet 802	center and radius 742
analyzing 805	diameter 742
frames 824-832	table 739
Haar 214	Hamming 611-612
Malvar 895	Hann 611-612, 624
orthonormal 802	Kaiser 611-612
packet 895	rectangular 611
pyramid decomposition 875	Windowed Fourier transform, see
transform (WT) 803-821	Short-time Fourier transform
continuous 803-805	Wolf, J. 58
discrete 874	Wolf sunspot number 58, 493
discretization 822-824	F 50
inverse (IWT) 805	Z
orthonormal 802	Zak transform (ZT) 575-577,
properties 810-815	777-781
properties, table 814	isomorphism 576-577
Waviness 308	properties 576
Weyl, H. 745	Zero 77, 628
Whale 52, 832	Zero-crossing 356-359, 900
White	Zorn, M. 165
Gaussian noise 335	Zorn's lemma 165
noise process 614	z-Transform 554-560
Wide sense stationary (WSS) 614-615	existence 557-560
Wiener, N. 615, 686	filter design 626-632
Wiener	inverse 566-571
filter 686	contour integration 566-567
-Khinchin theorem 615-616	Laurent series 567-568
Wigner, E. 761, 789	partial fractions 570
Wigner-Ville distribution (WVD) 760-766	table lookup 569-571
cross 764	one-sided 556
densities and marginals 766-769	properties 561-565
interference- (cross-) term 761, 769-770	region of convergence (ROC) 555
properties 763-766	table 569