

Processing:
a programming
handbook for
visual designers
and artists

Casey Reas
Ben Fry

The MIT Press
Cambridge, Massachusetts
London, England

© 2007 Massachusetts Institute of Technology

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without permission in writing from the publisher.

MIT Press books may be purchased at special quantity discounts for business or sales promotional use. For information, please email special_sales@mitpress.mit.edu or write to Special Sales Department, The MIT Press, 55 Hayward Street, Cambridge, MA 02142.

Printed and bound in the United States of America.

Library of Congress Cataloging-in-Publication Data

Reas, Casey.

Processing : a programming handbook for visual designers and artists / Casey Reas & Ben Fry ; foreword by John Maeda.

p. cm.

Includes bibliographical references and index.

ISBN 978-0-262-18262-1 (hardcover : alk. paper)

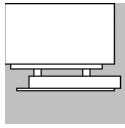
1. Computer programming. 2. Computer graphics—Computer programs. 3. Digital art—Computer programs. 4. Art—Data processing. 5. Art and technology. I. Fry, Ben. II. Title.

QA76.6.R4138 2007

005.1—dc22

2006034768

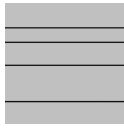
10 9 8 7 6 5 4 3 2 1



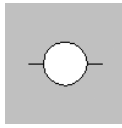
29



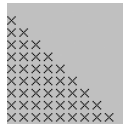
34



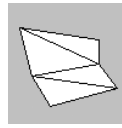
45



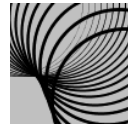
57



67



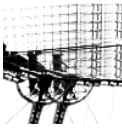
72



84



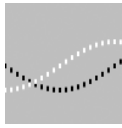
91



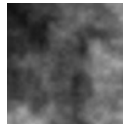
99



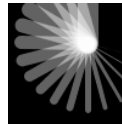
113



121



131



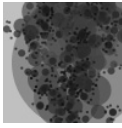
141



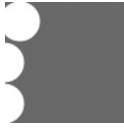
189



192



204



208



221



225



233



244



247



289



297



307



320



324



331



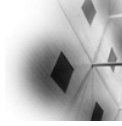
336



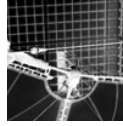
344



352



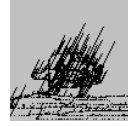
354



359



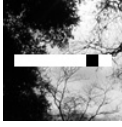
409



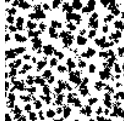
415



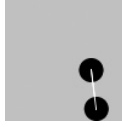
447



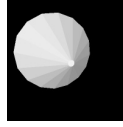
451



472



493



530



535



551

Contents

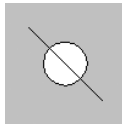
xix	Foreword	279	Motion 1: Lines, Curves
xxi	Preface	291	Motion 2: Machine, Organism
1	Processing...	301	Data 4: Arrays
9	Using Processing	315	Image 2: Animation
17	Structure 1: Code Elements	321	Image 3: Pixels
23	Shape 1: Coordinates, Primitives	327	Typography 2: Motion
37	Data 1: Variables	333	Typography 3: Response
43	Math 1: Arithmetic, Functions	337	Color 2: Components
51	Control 1: Decisions	347	Image 4: Filter, Blend, Copy, Mask
61	Control 2: Repetition	355	Image 5: Image Processing
69	Shape 2: Vertices	367	Output 1: Images
79	Math 2: Curves	371	Synthesis 3: Motion and Arrays
85	Color 1: Color by Numbers	377	Interviews 3: Animation, Video
95	Image 1: Display, Tint	395	Structure 4: Objects I
101	Data 2: Text	413	Drawing 2: Kinetic Forms
105	Data 3: Conversion, Objects	421	Output 2: File Export
111	Typography 1: Display	427	Input 6: File Import
117	Math 3: Trigonometry	435	Input 7: Interface
127	Math 4: Random	453	Structure 5: Objects II
133	Transform 1: Translate, Matrices	461	Simulate 1: Biology
137	Transform 2: Rotate, Scale	477	Simulate 2: Physics
145	Development 1: Sketching, Techniques	495	Synthesis 4: Structure, Interface
149	Synthesis 1: Form and Code	501	Interviews 4: Performance, Installation
155	Interviews 1: Print	519	Extension 1: Continuing...
173	Structure 2: Continuous	525	Extension 2: 3D
181	Structure 3: Functions	547	Extension 3: Vision
197	Shape 3: Parameters, Recursion	563	Extension 4: Network
205	Input 1: Mouse I	579	Extension 5: Sound
217	Drawing 1: Static Forms	603	Extension 6: Print
223	Input 2: Keyboard	617	Extension 7: Mobile
229	Input 3: Events	633	Extension 8: Electronics
237	Input 4: Mouse II	661	Appendixes
245	Input 5: Time, Date	693	Related Media
251	Development 2: Iteration, Debugging	699	Glossary
255	Synthesis 2: Input and Response	703	Code Index
261	Interviews 2: Software, Web	705	Index



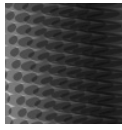
88



342



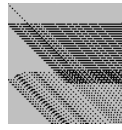
55



65



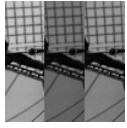
305



220



415



98



319



323



351



353



359



207



225



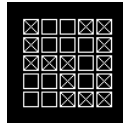
232



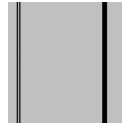
240



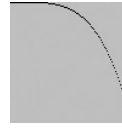
247



444



44



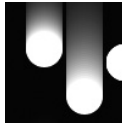
83



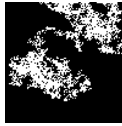
124



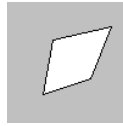
129



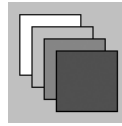
288



296



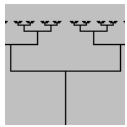
29



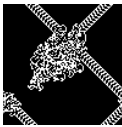
32



75



202



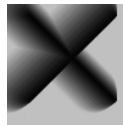
470



488



184



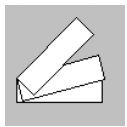
190



407



455



141



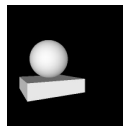
113



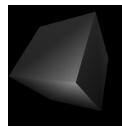
329



335



530



535



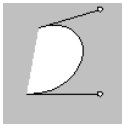
551

Contents by category

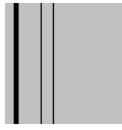
xix	Foreword	23	Shape 1: Coordinates, Primitives
xxi	Preface	69	Shape 2: Vertices
		197	Shape 3: Parameters, Recursion
1	Processing...	461	Simulate 1: Biology
9	Using Processing	477	Simulate 2: Physics
		17	Structure 1: Code Elements
85	Color 1: Color by Numbers	173	Structure 2: Continuous
337	Color 2: Components	181	Structure 3: Functions
51	Control 1: Decisions	395	Structure 4: Objects I
61	Control 2: Repetition	453	Structure 5: Objects II
37	Data 1: Variables	149	Synthesis 1: Form and Code
101	Data 2: Text	255	Synthesis 2: Input and Response
105	Data 3: Conversion, Objects	371	Synthesis 3: Motion and Arrays
301	Data 4: Arrays	495	Synthesis 4: Structure, Interface
145	Development 1: Sketching, Techniques	133	Transform 1: Translate, Matrices
251	Development 2: Iteration, Debugging	137	Transform 2: Rotate, Scale
217	Drawing 1: Static Forms	111	Typography 1: Display
413	Drawing 2: Kinetic Forms	327	Typography 2: Motion
95	Image 1: Display, Tint	333	Typography 3: Response
315	Image 2: Animation		
321	Image 3: Pixels	155	Interviews 1: Print
347	Image 4: Filter, Blend, Copy, Mask	261	Interviews 2: Software, Web
355	Image 5: Image Processing	377	Interviews 3: Animation, Video
205	Input 1: Mouse I	501	Interviews 4: Performance, Installation
223	Input 2: Keyboard		
229	Input 3: Events	519	Extension 1: Continuing...
237	Input 4: Mouse II	525	Extension 2: 3D
245	Input 5: Time, Date	547	Extension 3: Vision
427	Input 6: File Import	563	Extension 4: Network
435	Input 7: Interface	579	Extension 5: Sound
43	Math 1: Arithmetic, Functions	603	Extension 6: Print
79	Math 2: Curves	617	Extension 7: Mobile
117	Math 3: Trigonometry	633	Extension 8: Electronics
127	Math 4: Random		
279	Motion 1: Lines, Curves	661	Appendixes
291	Motion 2: Machine, Organism	693	Related Media
367	Output 1: Images	699	Glossary
421	Output 2: File Export	703	Code Index
		705	Index



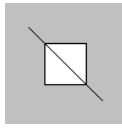
29



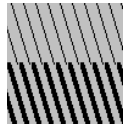
30



44



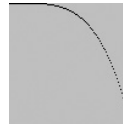
55



63



70



83



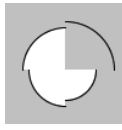
88



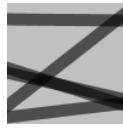
97



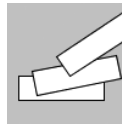
113



124



128



137



174



186



200



206



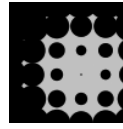
219



225



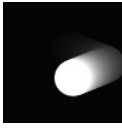
231



239



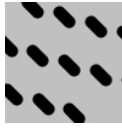
246



281



293



306



316



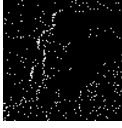
322



329



334



340



349



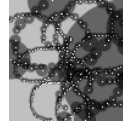
353



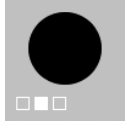
356



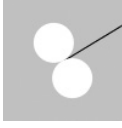
406



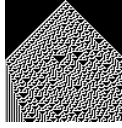
414



441



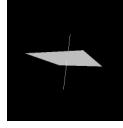
458



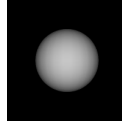
464



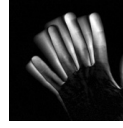
484



530



535



551

Extended contents

xix	Foreword by John Maeda	23	Shape 1: Coordinates, Primitives
xxi	Preface	23	Coordinates size()
xxi	Contents	25	Primitive shapes point(), line(), triangle(), quad(), rect(), ellipse(), bezier()
xxii	How to read this book	31	Drawing order
xxiii	Casey's introduction	31	Gray values background(), fill(), stroke(), noFill(), noStroke()
xxiv	Ben's introduction	33	Drawing attributes smooth(), noSmooth(), strokeWeight(), strokeCap(), strokeJoin()
xxv	Acknowledgments	34	Drawing modes ellipseMode(), rectMode()
1	Processing...	37	Data 1: Variables
1	Software	37	Data types int, float, boolean, true, false
3	Literacy	38	Variables =
4	Open	40	Processing variables width, height
4	Education	43	Math 1: Arithmetic, Functions
6	Network	43	Arithmetic +, -, *, /, %
7	Context	47	Operator precedence, Grouping ()
9	Using Processing	48	Shortcuts ++, --, +=, -=, *=, /=, -
9	Download, Install	49	Constraining numbers ceil(), floor(), round(), min(), max()
9	Environment		
10	Export		
11	Example walk-through		
16	Reference		
17	Structure 1: Code Elements		
17	Comments //, /* */		
18	Functions		
18	Expressions, Statements “,”, “,”		
20	Case sensitivity		
20	Whitespace		
20	Console print(), println()		

51	Control 1: Decisions	101	Data 2: Text
51	Relational expressions	102	Characters
	>, <, >=, <=, ==, !=		char
53	Conditionals	103	Words, Sentences
	if, else, {}		String
57	Logical operators		
	, &&, !	105	Data 3: Conversion, Objects
61	Control 2: Repetition	105	Data conversion
61	Iteration		boolean(), byte(), char(),
	for		int(), float(), str()
65	Nested iteration	107	Objects
67	Formatting code blocks		“.”,
			PImage.width, PImage.height,
69	Shape 2: Vertices		String.length,
69	Vertex		String.startsWith(),
	beginShape(), endShape(),		String.endsWith();
	vertex()		String.charAt(),
71	Points, Lines		String.toCharArray(),
72	Shapes		String.substring(),
74	Curves		String.toLowerCase(),
	curveVertex(), bezierVertex()		String.toUpperCase(),
			String.equals()
79	Math 2: Curves	111	Typography 1: Display
79	Exponents, Roots	112	Loading fonts, Drawing text
	sq(), sqrt(), pow()		PFont, loadFont(),
80	Normalizing, Mapping		textFont(), text()
	norm(), lerp(), map()	114	Text attributes
83	Simple curves		textSize(), textLeading(),
			textAlign(), textWidth()
85	Color 1: Color by Numbers	117	Math 3: Trigonometry
86	Setting colors	117	Angles, Waves
89	Color data		PI, QUARTER_PI, HALF_PI,
	color, color()		TWO_PI, sin(), cos(),
89	RGB, HSB		radians(), degrees()
	colorMode()	123	Circles, Arcs, Spirals
93	Hexadecimal		arc()
95	Image 1: Display, Tint		
96	Display	127	Math 4: Random
	PImage, loadImage(), image()	127	Unexpected numbers
97	Image color, Transparency		random(), randomSeed()
	tint(), noTint()	130	Noise
			noise(), noiseSeed()

133	Transform 1: Translate, Matrices	181	Structure 3: Functions
133	Translation	182	Abstraction
	translate()	183	Creating functions
134	Controlling transformations		void
	pushMatrix(), popMatrix()	193	Function overloading
137	Transform 2: Rotate, Scale	194	Calculating and returning values
137	Rotation, Scaling		return
	rotate(), scale()	197	Shape 3: Parameters, Recursion
139	Combining transformations	197	Parameterized form
142	New coordinates	201	Recursion
145	Development 1: Sketching, Techniques	205	Input 1: Mouse I
145	Sketching software	205	Mouse data
146	Programming techniques		mouseX, mouseY,
			pmouseX, pmouseY
149	Synthesis 1: Form and Code	212	Mouse buttons
150	Collage Engine		mousePressed, mouseButton
151	Riley Waves	213	Cursor icon
152	Wilson Grids		cursor(), noCursor()
153	Mandelbrot Set		
155	Interviews 1: Print	217	Drawing 1: Static Forms
157	Jared Tarbell.	218	Simple tools
	<i>Fractal.Invaders, Substrate</i>	221	Drawing with images
161	Martin Wattenberg.	223	Input 2: Keyboard
	<i>Shape of Song</i>	224	Keyboard data
165	James Paterson.		keyPressed, key
	<i>The Objectivity Engine</i>	227	Coded keys
169	LettError.		keyCode
	<i>RandomFont Beowolf</i>	229	Input 3: Events
173	Structure 2: Continuous	229	Mouse events
173	Continuous evaluation		mousePressed(),
	draw(), frameRate(),		mouseReleased(),
	frameCount		mouseMoved(), mouseDragged()
177	Controlling the flow	232	Key events
	setup(), noLoop(),		keyPressed(), keyReleased()
178	Variable scope	235	Controlling the flow
			loop(), redraw()

237	Input 4: Mouse II	301	Data 4: Arrays
237	Constrain	303	Using arrays
	constrain()		Array, [], new, Array.length
238	Distance	306	Storing mouse data
	dist()	309	Array functions
239	Easing		append(), shorten(),
	abs()		expand(), arraycopy()
242	Speed	312	Two-dimensional arrays
243	Orientation		
	atan2()	315	Image 2: Animation
245	Input 5: Time, Date	316	Sequential images
245	Seconds, Minutes, Hours	319	Images in motion
	second(), minute(), hour(),		
	millis()	321	Image 3: Pixels
249	Date	321	Reading pixels
	day(), month(), year()		get()
		324	Writing pixels
			set()
251	Development 2: Iteration, Debugging		
251	Iteration	327	Typography 2: Motion
252	Debugging	327	Words in motion
		331	Letters in motion
255	Synthesis 2: Input and Response		
256	Tennis	333	Typography 3: Response
257	Cursor. Peter Cho	333	Responsive words
258	Typing	335	Responsive letters
259	Banded Clock. Golan Levin		
		337	Color 2: Components
261	Interviews 2: Software, Web	337	Extracting color
263	Ed Burton. <i>Sodaconstructor</i>		red(), blue(), green(),
267	Josh On. <i>They Rule</i>		alpha(), hue(), saturation(),
271	Jürg Lehni. <i>Hektor and Scriptographer</i>		brightness(),
275	Auriea Harvey and Michaël Samyn.	341	Dynamic color palettes
	<i>The Endless Forest</i>		
279	Motion 1: Lines, Curves	347	Image 4: Filter, Blend, Copy, Mask
279	Controlling motion	347	Filtering, Blending
284	Moving along curves		filter(), blend(),
287	Motion through transformation		blendColor()
		353	Copying pixels
			copy()
291	Motion 2: Machine, Organism	354	Masking
291	Mechanical motion		mask()
295	Organic motion		

355	Image 5: Image Processing	421	Output 2: File Export
356	Pixels	421	Formatting data
	pixels[], loadPixels(),		nf()
	updatePixels(), createImage()	422	Exporting files
359	Pixel components		saveStrings(), PrintWriter,
360	Convolution		createWriter(),
364	Image as data		PrintWriter.flush(),
			PrintWriter.close(), exit()
367	Output 1: Images		
368	Saving images	427	Input 6: File Import
	save()	428	Loading numbers
369	Saving sequential images		loadStrings(),
	saveFrame()		split(), splitTokens()
371	Synthesis 3: Motion and Arrays	431	Loading characters
372	Centipede. Ariel Malka		WHITESPACE
373	Chronodraw. Andreas Gysin	435	Input 7: Interface
374	AmoebaAbstract_03. Marius Watz	436	Rollover, Button, Dragging
375	Mr. Roboto. Leon Hong	442	Check boxes, Radio buttons
		448	Scrollbar
377	Interviews 3: Animation, Video		
379	Motion Theory. R.E.M. "Animal"	453	Structure 5: Objects II
383	Bob Sabiston. <i>Waking Life</i>	453	Multiple constructors
387	Jennifer Steinkamp. <i>Eye Catching</i>	454	Composite objects
391	Semiconductor. <i>The Mini-Epoch Series</i>	456	Inheritance
			extends, super
395	Structure 4: Objects I		
395	Object-oriented programming	461	Simulate 1: Biology
398	Using classes and objects	461	Cellular automata
	class, Object	469	Autonomous agents
406	Arrays of objects		
409	Multiple files	477	Simulate 2: Physics
		477	Motion simulation
413	Drawing 2: Kinetic Forms	481	Particle systems
414	Active tools	487	Springs
416	Active drawings		
		495	Synthesis 4: Structure, Interface
		496	WithoutTitle. Lia
		497	Pond. William Ngan
		498	Swingtree. ART+COM,
			Andreas Schlegel
		499	SodaProcessing. Ed Burton

501	Interviews 4: Performance, Installation	579	Extension 5: Sound. R. Luke DuBois
503	SUE.C. <i>Mini Movies</i>	579	Music and sound programming in the arts
507	Chris Csikszentmihályi. <i>DJI, Robot Sound System</i>	582	Sound and musical informatics
511	Golan Levin, Zachary Lieberman. <i>Messa di Voce</i>	584	Digital representation of sound and music
515	Marc Hansen. <i>Listening Post</i>	588	Music as information
519	Extension 1: Continuing...	591	Tools for sound programming
519	Extending Processing	592	Conclusion
521	Processing and Java	593	Code
522	Other programming languages	599	Resources
525	Extension 2: 3D. Simon Greenwold	603	Extension 6: Print. Casey Reas
525	A short history of 3D software	603	Print and computers
526	3D form	606	High-resolution file export
531	Camera	608	Production
532	Material and lights	612	Conclusion
536	Tools for 3D	613	Code
538	Conclusion	615	Resources
539	Code	617	Extension 7: Mobile. Francis Li
545	Resources	617	Mobile software applications
547	Extension 3: Vision. Golan Levin	619	The mobile platform
547	Computer vision in interactive art	622	Programming for mobile phones
549	Elementary computer vision techniques	624	Mobile programming platforms
552	Computer vision in the physical world	625	Conclusion
554	Tools for computer vision	626	Code
555	Conclusion	631	Resources
556	Code	633	Extension 8: Electronics. Hernando Barragán and Casey Reas
561	Resources	633	Electronics in the arts
563	Extension 4: Network. Alexander R. Galloway	635	Electricity
563	The Internet and the arts	637	Components
565	Internet protocols and concepts	638	Circuits
569	Network tools	639	Microcontrollers and I/O boards
571	Conclusion	642	Sensors and communication
572	Code	646	Controlling physical media
576	Resources	648	Conclusion
		649	Code
		658	Resources

661	Appendix A: Order of Operations
663	Appendix B: Reserved Words
664	Appendix C: ASCII, Unicode
669	Appendix D: Bit, Binary, Hex
673	Appendix E: Optimization
679	Appendix F: Programming Languages
686	Appendix G: Code Comparison
693	Related Media
699	Glossary
703	Code Index
705	Index

Code Index

This index contains all of the Processing language elements introduced within this book. The page numbers refer to the first use.

- ! (logical NOT), 57
- != (inequality), 52
- % (modulo), 45
- && (logical AND), 57
- () (parentheses)
 - for functions, 18
 - for precedence, 47
- * (multiply), 44
- *= (multiply assign), 49
- + (addition), 43
- ++ (increment), 48
- += (add assign), 48
- , (comma), 18
- (minus), 44
- (decrement), 48
- = (subtract assign), 48
- . (dot), 107
- / (divide), 44
- /= (divide assign), 49
- /* */ (comment), 18
- // (comment), 17
- ;(semicolon), 19
- < (less than), 51
- <= (less than or equal to), 52
- = (assign), 38
- == (equality), 52
 - for String objects, 109
- > (greater than), 51
- >= (greater than or equal to), 52
- [] (array access), 301
 - 2D arrays, 312
 - arrays of objects, 406
- { } (braces), 53
 - and variable scope, 178
- || (logical OR), 57
- # (hex color), 93
- abs(), 241
- alpha(), 338
- ambient(), 533
- ambientLight(), 533
- append(), 309
- arc(), 124
- arraycopy, 310
- Array, 301
 - length, 304
- atan2(), 243
- background(), 31
- beginRaw(), 531
- beginRecord(), 607
- beginShape(), 69
- bezier(), 30
- bezierVertex(), 75
- blend(), 351
- blendColor(), 352
- blue(), 337
- boolean, 38
- boolean(), 106
- brightness(), 338
- byte, 38
- byte(), 106
- camera(), 531
- Capture, 556
- ceil(), 49
- char, 38, 102
- char(), 106
- class, 395
- Client, 567
- color, 38, 89
- color(), 89
- colorMode(), 91
- constrain(), 237
- copy(), 353
- cos(), 118
- createGraphics(), 614
- createImage(), 362
- createWriter(), 423
- cursor(), 213
- curveVertex(), 74
- day(), 249
- degrees(), 117
- directionalLight(), 536
- dist(), 238
- draw(), 173
- ellipse(), 30
- ellipseMode(), 34
- else, 55
- else if, 56
- endRaw(), 531
- endRecord(), 607
- endShape(), 69
- exit(), 422
- expand(), 309
- extends, 456
- false, 38
- fill(), 32
- filter(), 347
- float, 37
- float(), 106
- floor(), 49
- for, 61
- frameCount, 173
- frameRate(), 173
- get(), 321
- green(), 337
- HALF_PI, 117
- height, 40
- hour(), 245
- HSB, 89
- hue(), 338
- if, 53
- image(), 96
- int, 37
- int(), 107
- key, 225
- keyCode, 227
- keyPressed, 224
- keyPressed(), 232
- keyReleased(), 232
- lerp(), 81
- lightSpecular(), 536
- line(), 27
- loadFont(), 112
- loadImage(), 96
- loadPixels(), 356
- loadStrings(), 428
- loop(), 235

- map(), 81
- mask(), 354
- max(), 50
- millis(), 248
- min(), 50
- minute(), 245
- month(), 249
- mouseButton, 212
- mouseDragged(), 229
- mouseMoved(), 229
- mousePressed, 212
- mousePressed(), 229
- mouseReleased(), 229
- mouseX, 205
- mouseY, 205

- new
 - for arrays*, 303
 - for objects*, 399
- nf(), 422
- noCursor(), 213
- noFill(), 33
- noise(), 130
- noiseSeed(), 131
- noLoop(), 178
- norm(), 80
- noSmooth(), 33
- noStroke(), 33
- noTint(), 97

- Object, 107, 395

- PFont, 112
- PI, 117
- PImage, 96
- pixels[], 356
- pmouseX, 208
- pmouseY, 208
- point(), 25
- pointLight(), 536
- popMatrix(), 134
- pow(), 80
- print(), 20
- println(), 20
- PrintWriter, 423
 - close(), 423
 - flush(), 423
 - println(), 424
- pushMatrix(), 134

- quad(), 29
- QUARTER_PI, 117

- radians(), 117
- random(), 127
- randomSeed(), 129
- rect(), 29
- rectMode(), 34
- red(), 337
- redraw(), 235
- return, 194
- RGB, 89
- rotate(), 137
- round(), 50

- saturation(), 338
- save(), 368
- saveFrame(), 369
- saveStrings(), 422
- scale(), 138
- second(), 245
- Server, 567
- set(), 324
- setup(), 177
- shorten(), 309
- sin(), 118
- size(), 24
 - with P3D*, 528
 - with OpenGL*, 528
 - with PDF*, 607
- smooth(), 33
- specular(), 536
- split(), 429
- splitTokens(), 430
- spotLight(), 536
- sq(), 79
- sqrt(), 79
- str(), 107
- String, 103
 - length(), 108
 - endsWith(), 108
 - equals(), 109
 - startsWith(), 108
 - substring(), 109
 - toCharArray(), 108
 - toLowerCase(), 109
 - toUpperCase(), 109
- stroke(), 32
- strokeCap(), 33
- strokeJoin(), 33
- strokeWeight(), 33
- super, 456

- text(), 112
- textAlign(), 115
- textFont(), 112
- textLeading(), 115
- textSize(), 114
- texture(), 536
- textWidth(), 116
- tint(), 97
- translate(), 133
- triangle(), 27
- true, 38
- TWO_PI, 117

- updatePixels(), 356

- vertex(), 69
- void, 187

- width, 40

- year(), 249

Index

This index contains mostly people, software, artwork, and programming languages. For topics, see the table of contents (pp. vii–xvii); for code, see the Code Index.

- 1:1 (Jevbratt), 566
3M Corporation, 553
3 *Stoppages Étalon* (Duchamp), 127
7–11 Email list, 563
- AARON, 218
Aesthetics and Computation Group (ACG), xxiii, 682
Achituv, Romy, 549
ActionScript, 158, 166, 522–523, 565, 680–681, 686–687, 689, 691
Adair, Sandra, 384
Adobe, 4, 169, 683
Adobe After Effects, 166, 327, 379, 387
Adobe Flash, 157–158, 165–166, 267–268, 275, 278, 327, 436, 564–565, 624, 629, 642, 680–681, 683, 686, 701
Adobe Flash Lite, 624, 681
Adobe Garamond (font), 112
Adobe Illustrator, xxiii, 30, 77, 166, 143, 217, 271, 273, 607–608, 683
Adobe Photoshop, xxiii, 95, 166, 268, 276, 347, 355, 360, 384, 387–388, 391–392, 607–608, 611, 683
Adobe Premiere, 391–392
Adobe Streamline, 166
AAC (Advanced Audio Coding), 585
AIFF (Audio Interchange File Format), 585–586, 699
Aldus PageMaker, 605
Alexander, Ryan, 380
Alias Maya, 379, 387–388, 537, 680
AltSys, 170
Andrade, Laura Hernandez, 4
Apple IIe, xxiii
Apple Audio Units (AU), 591
Apple Computer, 3, 111, 537, 585, 699
Apple Logic Audio, 503, 591
Apple Mac G3, 383
Apple Mac G4, 383
Apple Macintosh (Mac), 9–11, 95, 111–112, 169, 205, 227, 367, 383, 521, 568–569, 574, 604, 639, 665, 682, 685
Apple Mac Mini, 639
Apple Mac OS, 264, 435, 665–666, 681
Apple Mac OS X, 16, 170, 435, 645, 649, 684
Apple QuickTime, 367, 383–384, 387–388
AppleScript, 681
Arduino, 521, 633, 640, 641, 645–646, 648–649, 681, 685
Arp, Jean, 127
Ars Electronica Festival, 618
ART+COM, 498
ASCII (American Standard Code for Information Interchange), 102–103, 226–227, 549, 565, 664–668, 670, 691, 699
Athena, 387
ATI, 537
AT&T/Bell, 564
Audacity, 591
AutoCAD, 217, 529, 537
Autodesk 3ds Max, 268, 276, 391–392, 537
AutoDesk Revit, 537
AutoLISP, 522, 681
Autonomea, 564
Avid/Digidesign Pro Tools, 591
AVR (Atmel), 640
awk, 517, 684
- Babbitt, Milton, 580–581
Bach, J. S., 581
Bailey, Chris, 581
Balkin, Amy, 267
Baran, Paul, 564
Barr, Alfred, 291
Barragán, Hernando, 633
BASIC, xxiii, xxiv, 152, 264, 522, 604–605, 640, 642, 681
BASIC Stamp 2 (Parallax), 640
BasicX–24 (NetMedia), 642
Bass, Saul, 327
Baumgärtel, Tilman, 564
Bauhaus, 149
BBC Acorn Archimedes, 264
Beach Culture, 605
Beethoven, Ludwig van, 581
BEFLIX, 315, 681
Bell Laboratories, 315, 580–581, 604
Bentley Systems
 GenerativeComponents, 537
Berliner, Emile, 579
Berlow, David, 170
Bernard (a k a Flip 1), 508
BIAS Peak, 591
BigEye, 554
Binary Runtime Environment for Wireless (BREW), 625
Binary space partition (BSP), 527
Binder, Maurice, 327
bitforms gallery, 164, 166–167, 525, 547, 603, 633
Bittorent, 571
Blackwell, Lewis, 605
Blender, 276, 576
Blinkenlights (Chaos Computer Club), 618
Blonk, Jaap, 511
Bluetooth, 619, 621–622, 624, 641, 645, 683
Blyth, Steven, 512
Boids (Reynolds), 295, 473, 475, 497
Boole, George, 38, 61, 669
Boolean algebra, 38
Boulez, Pierre, 581
Braitenberg, Valentino, 473–474
Brakhage, Stan, 413
Brecht, Bertolt, 564
Brooklyn Academy of Music (BAM), 515–516
Brown, Robert, 295
Brownian motion, 295
Brunelleschi, Filippo, 525
Bunting, Heath, 563–564
Bureau of Inverse Technology, 548, 634
Burke, Phil, 592
Burton, Ed, 263–264, 413, 499
Byrne, David, 581

- C, 7, 264, 515–517, 522–523, 592, 640, 642, 682–685, 693, 697
- C++, 264, 271, 383, 507–508, 511–512, 515–516, 522–523, 555, 592, 599, 640, 679, 681–682
- CAD (computer-aided drawing software), 217, 526, 537–538
- Cage, John, 127, 579
- CalArts School of Art, 564
- California Institute of Technology (Caltech), 388, 549
- Cameron, Dan, 387
- Campbell, Jim, 549
- Carmack, John, 525
- Carnegie Mellon University, xxi
- Carnivore, 566, 568–569
- Carson, David, 605
- Cascading Style Sheets (CSS), 93
- CCRMA Synthesis ToolKit (STK), 592
- Chang, Zai, 6
- Cheese* (Möller), 549
- Cho, Peter, 257, 327
- CIA World Fact Book, 267
- Citron, Jack, 315
- CityPoems*, 617, 624
- Chuck, 592, 682
- Cloaca* (Delvoye), 461
- Clash of the Titans*, 387
- Close, Chuck, 606
- CODE* (Petzold), 648
- Cohen, Harold, 218
- Columbia–Princeton Electronic Music Center, 580
- Commodore C-64, 272
- Commodore VC-20, 272
- Common Lisp, 592
- Complexification.net*, 6, 157
- Computational Beauty of Nature, The* (Flake), 469
- Computers and Automation*, 603
- Computer Clubhouse, 680
- Computer Lib / Dream Machines (Nelson), 3
- Computer Vision Homepage (Huber), 552
- Coniglio, Mark, 512
- “Constituents for a Theory of the Media” (Enzensberger), 564
- Conway, John, 461, 463, 467–468, 475
- Cook, Perry, 592
- Cooper, Muriel, 327
- Cope, David, 581
- CorelDRAW, 608
- Cosic, Vic, 563–564
- Costabile, Sue (SUE.C), 503–504
- Craighead, Alison, 618
- Crawford, David, 316
- Crystal Castle, 525
- Csikszentmihályi, Chris, 507–508, 634
- CSIRAC, 580
- Csuri, Charles, 217
- Cuba, Larry, 1, 315
- Cullen, Mathew, 379–380
- CVJit, 554
- Cybernetic Serendipity, 101, 603
- Cycling '74, 554, 592
- Cyclops, 554
- Dada, 149–150
- Davies, Char, 526
- Davis, Joshua, 564–565
- Deck, Barry, 112
- Deleuze and Guattari, 564
- Delvoye, Wim, 461
- De Mol, Gerry, 275
- Design By Numbers (DBN), xxiv, 552–523, 682
- Designers Republic, The, 605
- Dextro, 316
- Dialtones* (Levin et al.), 617–618
- Digidesign, 587, 591
- Dine, Jim, 606
- DJ I, Robot Sound System*, 506–509
- Dodgeball, 617, 624
- Domain Name System (DNS), 566
- DrawBot, 169, 682, 684
- Drawing with Computers* (Wilson), 152, 217, 604
- Drawn* (Lieberman), 413
- DuBois, R. Luke, 579
- Duchamp, Marcel, 127, 633
- Dunne, Tony, 634
- Dürer, Albrecht, 525, 612
- DXF, 520, 529–531
- Dynabook, 3
- Eagle, 272
- écal (école cantonale d’art de Lausanne), 271
- Eclipse, 571, 625
- ECMAScript, 681, 683
- Edelweiss Series* (Maywa Denki), 634
- Egerton, Harold, 295
- Edison, Thomas, 579
- Eighth Istanbul Biennial, 387
- Eimart, Herbert, 580
- Electronic Arts, 585
- ELIZA, 101
- Emacs, 516
- Emigre, 605
- End of Print, The* (Blackwell), 605
- Endless Forest, The* (Tale of Tales), 274–277
- Engelbart, Douglas, 205
- Eno, Brian, 581
- Enron, 268
- Enzensberger, Hans Magnus, 564
- EPS, 606
- Euler’s method, 7, 494
- Every Icon* (Simon), 565
- Evolved Virtual Creatures* (Sims), 295
- Experiments in Art and Technology (E.A.T.), 633
- Extend Script, 683
- Eye magazine, 605
- Eye Catching* (Steinkamp), 386–389
- EyesWeb, 554–555
- EZIO (NIQ), 642
- Feingold, Ken, 633
- Ferro, Pablo, 327
- Final Cut Pro (FCP), 383, 503
- Final Scratch, 507
- Fischinger, Oskar, 413
- Fisher, Robert, 552
- Flake, Gary William, 469
- Flight404.com*, 6
- Flight Simulator, 525
- Foldes, Peter, 315
- FontLab, 170
- Fontographer, 170
- Fortran, 522
- Fractal Invaders* (Tarbell), 156–159
- Franceschini, Amy, 267
- Franke, Uli, 260, 271
- Free Radicals*, 413
- Friendster, 617
- Fourier, Jean-Baptiste-Joseph, 584
- Fourier transform, 585, 588, 590
- Futurist, 279, 579
- Gabo, Nam, 633
- Galloway, Alexander R., 563
- Game of Life, 461, 463, 465–466, 468, 475
- Gardner, Martin, 461, 463
- Garton, Brad, 581
- Gerhardt, Joseph, 391–392
- Gestalt psychology, 584

GIF, 95–96, 98–99, 421, 700–701
 Giroir, Jonathan, 506–509
 Google, 568, 617
 GPS (Global positioning system), 619, 621
 Graffiti, 223
 GRASS, 681
 Groeneveld, Dirk, 333
 GNU Image Manipulation Program (GIMP), 95, 347, 355, 607–608
 GNU Public License (GPL), 271
 Gnutella, 566, 571
 GPU (graphics processing unit), 536–537
 Graphomat Z64 (Zuse), 603
 Greenwold, Simon, 525
 Greie, Antye (AGF), 503–504
 Grzinic, Marina, 563
 GUI (Graphical user interface), 435–436, 448, 450, 499, 604, 634, 679–680, 683, 685, 700
 Gutenberg, Johannes, 111
 Gutenberg archive, 433
 Guttmann, Newmann, 580
 Gysin, Andreas, 373

Hall, Grady, 379
 Handel, George Frideric, 581
 Hansen, Mark, 515–516, 634
 Harmon, Leon, 604
 Harvard University, xxi
 Harvey, Auriea, 275
 Hewlett-Packard (HP), 604, 610
 Hawkinson, Tim, 633
 Hawtin, Richie, 507
 Hébert, Jean-Pierre, 217, 606
Hektor (Lehni, Franke), 260, 270–273
 Henry, John, 507
 Henry, Pierre, 580
 Hiller, Lejaren, 581
 Hoefler, Jonathan, 112
 Hodgkin, Robert, 6, 692
 Hokusai, 612
 Hongik University, 5
 Hong, Leon, 5, 375
 Hooke's law, 263, 487
 Howard Wise gallery, 603
 HTML (HyperText Markup Language), 9–11, 93, 268, 427, 549, 564–565, 568–569, 621, 624, 665–666, 684
 HTTP (Hypertext Transfer Protocol), 567–569, 623

Huber, Daniel, 552
 Huff, Kenneth A., 606
 Hypermedia Image Processing Reference (HIPR), 552
 HyperTalk, 522

IANA, 569
 IBM, 315, 537, 580, 585, 604, 620, 702
 IC (integrated circuit), 639, 647
 I-Cube X (Infusion Systems), 642
 IEEE 1394 camera, 556
If/Then (Feingold), 633
 Igarashi, Takeo, 538
 Igoe, Tom, 635, 648
 Ikarus M, 170
Incredibles, The, 315
 Internet Explorer, 565
 Internet Protocol (IP), 566–567, 569, 589, 645
 Impressionist, 279
Inaudible Cities: Part One (Semiconductor), 392
 InDesign, 683
 Infrared, 553, 621
 Inge, Leif, 581
 Inkscape, 77, 607–608
Installation (Greenwold), 526
 Institute of Contemporary Arts (ICA), 101, 522
 Intel Integrated Performance Primitives (IPP), 512, 555
 Interaction Design Institute Ivrea (IDI), xxi, 634
i|o 360°, 565
I/O/D 4 ("The Webstalker"), 566
 IRCAM, 554, 581, 592
 Ishii, Hiroshi, 634
 Ishizaki, Suguru, 327
 ISO 216 standard, 611
 Iwai, Toshio, 512, 549

James, Richard (Aphex Twin), 582
 Jarman, Ruth, 391–392
 Java, 7, 9–11, 146, 161–162, 263–264, 271, 499, 521–523, 528, 555, 564–565, 571, 574, 592, 622, 625–626, 642, 663, 673, 677, 679–683, 686–690, 699–700
 Java 2 Micro Edition (J2ME), 625
 Java applet, 9–11, 264, 521, 656, 657, 675, 699
 Java Archive (JAR), 10–11, 700
 Java Core API, 271

JavaScript, 268, 271, 522, 624, 680, 681, 683
 Java Virtual Machine (JVM), 680
 Jeremijenko, Natalie, 548
 Jevbratt, Lisa, 566
 jMax, 592
 Jodi, 563–566
 Jones, Crispin, 634
 Jones, Ronald, 275
 Jonzun Crew, 508
 JPEG, 95–96, 162, 421, 606, 611, 620, 701
 JSyn (Java Synthesis), 592
 Julez, Bela, 603

Kay, Alan, 3
 Kim, Tai-kyung, 5
 Kimura, Mari, 582
 King's Quest, 525
 Klee, Paul, 217
 Knowlton, Kenneth C., 315, 604
 Krueger, Myron, 255, 512, 547
 Kusai, Lina, 275
 Kuwakubo, Ryota, 634

La Barbara, Joan, 511
 Langton, Chris, 469, 471
Putto8 2.2.2.2 (Rees), 524, 526
 LaserWriter, 111, 604
 Lee, Soo-jeong, 5
 Led Zeppelin, 161
Legible City, The (Shaw, Groeneveld), 333
 Lehni, Jürg, 260, 271–273
 Leibniz, Gottfried Wilhelm, 61
Letterscapes (Cho), 327
 LettError, 111, 168–170, 605
 Levin, Golan, 259, 333, 511–512, 547, 617–618
 Lewis, George, 582
 LeWitt, Sol, 217
 Li, Francis, 617
 Lia, 316, 496
 Lialina, Olia, 563–564
 Licko, Zuzana, 112, 605
 Lieberman, Zachary, 413, 512–512, 547
 Lifestreams, 425–426
 Limewire, 571
 Lingo, 522–523, 555, 565, 683, 686–687, 689, 691
 Linklater, Richard, 383
 Linotype, 111
 Linux, 4, 9–11, 508, 521, 568–569, 625, 645, 649

- Listening Post* (Rubin, Hansen), 514–517
- LISP, 101
- LiveScript, 683
- Local area network (LAN), 568–569
- Logo, xxiii, 2, 217, 522, 681
- Lovink, Geert, 564
- Lozano-Hemmer, Rafael, 546, 548
- Lucent Technologies, 515
- Lucier, Alvin, 590
- Luening, Otto, 580
- Lüsebrink, Dirk, 549
- Lye, Len, 413
- Machine Art exhibition, 291, 633
- Machine Perception Laboratories, 549
- MacMurtrie, Chico, 549
- Macromedia Director, 166, 387–388, 554–555, 642, 683, 686
- Maeda, John, xix, xxiii, xxiv, 3, 5, 158, 333, 564, 606, 682
- Malka, Ariel, 372
- Makela, P. Scott, 605
- Mandelbrot, Benoit, 153
- Manovich, Lev, 565
- Marble Madness, 525
- Marconi, Guglielmo, 579
- Marey, Étienne-Jules, 295
- Mark of the Unicorn Digital Performer, 591
- Markov chain, 581
- Marx, Karl, 267–268
- Massachusetts Institute of Technology (MIT), xix, xxiii, xxiv, 327, 634, 680, 682, 693, 695
- Masterman, Margaret, 101
- Mathews, Max, 580, 586, 591, 683
- MATLAB, 522
- Max/MSP/Jitter, 2, 503–504, 515–517, 522, 554–555, 571, 580, 592, 642, 683–685
- Maya Embedded Language (MEL), 680, 683
- Maywa Denki, 634
- McCarthy, John, 101
- McCartney, James, 592
- McCay, Winsor, 315
- McLaren, Norman, 413
- Medusa, 387
- MEL, 680, 683
- Mendel, Lucy, 507
- Messa di Voce* (Tmema et al.), 510–513, 547
- Metrowerks Codewarrior, 512
- Microsoft, 4, 111, 169, 436, 508, 525, 537, 585, 702
- Microsoft Direct3D, 537
- Microsoft Visual Basic, 436
- Microsoft Windows, 9, 11, 264, 367, 421, 435–436, 511, 521, 568, 625, 645, 649, 665–666, 685
- MIDI (Musical Instrument Digital Interface) 162, 554, 588–589, 591–592, 618, 621, 623, 642, 645, 683, 685
- Mignonneau, Laurent, 549
- MIME, 623
- Mims, Forest M., III, 648
- Mini-Epoch Series, The* (Semiconductor), 390–393
- Mini Movies* (AGF+SUE.C), 500, 502–505
- Minitasking* (Schoenerwissen/OfCD), 562, 566
- Minsky, Marvin, 547
- MIT Media Laboratory, xxiii, 327, 634, 680, 682, 702
- MixViews, 591
- MP3, 162, 421, 585, 621, 623
- MPEG–7, 549
- Mobile Processing, 521, 622–626, 683
- Mohr, Manfred, 217, 602, 606
- Möller, Christian, 549
- Moore, F. Richard, 592
- Mophon, 625
- Morisawa, 605
- Motion Theory, 378–381
- MTV, 384
- [murmur]*, 618
- Museum of Modern Art, The (MOMA), 291, 633
- MUSIC, 580, 591
- Musique concrète, 580–581
- Muybridge, Eadweard, 295, 373
- Myron, 555
- MySQL, 267–268
- Myst, 525
- Nakamura, Yugo, 565
- Nake, Frieder, 217, 603
- Napier, Mark, 566
- Napster, 507, 571
- Nees, Georg, 217, 603
- Nelson, Ted, 3
- “net.art”, 563–564
- net.art* (Baumgärtel), 564
- net.art 2.0* (Baumgärtel), 564
- NetBeans, 625
- Netscape Navigator, 565, 683
- Newton, Isaac, 477, 488
- New York University (NYU), 6, 634
- New York Times, The*, 150
- Ngan, William, 497
- Nimoy, Josh, 512
- Noll, A. Michael, 217, 603
- Nokia, 517, 618–619, 625
- Nmap, 569
- NSA (National Security Agency), 268
- NTNTNT* (Cal Arts), 564
- NTSC, 367
- NTT DoCoMo’s i-Mode, 624
- Nuendo, Steinberg, 591
- null, 40, 701
- NURBS (Non-uniform Rational B-splines), 526
- nVidia, 537
- Nyquist theorem, 585
- OBI, 529–531
- Objectivity Engine, The* (Paterson), 164–167
- Oliveros, Pauline, 582
- Olsson, Krister, 589
- Once-Upon-A-Forest* (Davis), 564
- On, Josh, 267–268
- oN-Line System (NLS), 205
- OpenCV, 512, 555
- OpenGL, 512, 520, 528, 531, 537, 554, 684
- Open source, 4, 268, 271, 512, 521, 555, 591, 625–626, 640, 684
- OpenType, 111, 169
- Oracle database, 264
- OSC (Open Sound Control), 516–517, 571, 589
- oscP5 (Schlegel), 571
- Osmose* (Davies), 526
- O’Sullivan, Dan, 635, 648
- Oswald, John, 581
- Owens, Matt, 565
- Pad, 435
- Paik, Nam June, 633
- PAL, 367
- Palm Pilot, 223, 625
- Palm OS, 625
- Panasonic, 625
- Papert, Seymour, 2, 217
- Parallax, 640
- Parallel Development, 516
- Pascal, 522

- Paterson, James, 165–166, 316, 565, 606
- Paul, Les, 580
- PBASIC, 642, 681
- PC, 10, 227, 388, 625, 665, 682
- PCB (printed circuit board), 639, 640
- PCM (pulse–code modulation), 585–586, 699, 702
- PDF, 520, 606–608, 682
- Pelletier, Jean-Marc, 554
- Penny, Simon, 549
- Perl, 146, 515–517, 522–523, 565, 571, 681, 684
- Perlin, Ken, 130
- Personal area network (PAN), 621–622
- Petzold, Charles, 648
- Phidgets, 642
- Philips, 634
- PHP, 267–268, 522–523, 565, 682, 684
- PHPMyAdmin, 268
- Physical Computing* (O’Sullivan, Igoe), 648
- Piano Phases* (Reich), 293
- PIC (Microchip), 272, 640
- PIC Assembler, 271–272
- PIC BASIC, 681
- Pickard, Galen, 507
- Pickering, Will, 516
- Pixar, 315
- Pixillation* (Schwartz), 315
- PNG (Portable Network Graphics), 95–96, 98–99, 606, 622, 701
- Pocket PC, 625
- PoemPoints, 617
- Pong, 256, 590, 618
- PortAudio, 512
- PostScript, 111, 143, 169–170, 522, 604–605, 681
- Poynor, Rick, 605
- Practical Electronics for Inventors* (Scherz), 648
- Practice of Programming, The* (Kernighan, Pike), 52
- Praystation* (Davis), 564
- Public Enemy, 581
- Puckette, Miller, 2, 592, 684
- Pulse–code modulation (PCM), 585–586, 699, 702
- Pure Data (Pd), 592, 684–685
- Python, 146, 170, 517, 522–523, 681–682, 684
- Q*bert, 525
- Quartz Composer, 684
- Qualcomm, 625
- Quest3D, 275–276
- R, 515, 517
- Raby, Fiona, 634
- Radial, 503–504
- RAM, 701
- RandomFont Beowolf (LettError), 111, 168–170, 605
- Rauschenberg, Robert, 606
- Ray Gun*, 605
- Razorfish, 565
- RCA Mark II Sound Synthesizer, 580
- Readme!, 563
- Real-Time Cmix, 592
- Rees, Michael, 526
- Reeves, Alec, 585
- Reich, Steve, 293
- Reichardt, Jasia, 522
- Reiniger, Lotte, 315
- RenderMan, 315
- R.E.M. “Animal” (Motion Theory), 378–381
- ResEdit, 170
- Resnick, Mitchel, 471, 680
- Reynolds, Craig, 295, 473, 497
- Rhino, 271, 537
- Rich, Kate, 548
- Riley, Bridget, 151
- Ringtail Studios, 275
- Risset, Jean-Claude, 581
- RoboFog, 170
- Rokeby, David, 548, 554
- Rotoshop, 383–384, 413
- Royal Academy of Arts, 169
- Royal College of Art, 634
- Rozin, Danny, 549
- RS-232, 639, 554, 640, 645
- Rubin, Ben, 515, 634
- Ruby, 681, 684
- Ruby on Rails, 684
- Runge-Kutta method 7, 494
- Russolo, Luigi, 579
- Sabiston, Bob, 383–384, 413
- Saito, Tatsuya, 198, 529, 568
- Samyn, Michaël, 275
- Sauter, Joachim, 549
- Schaeffer, Pierre, 580
- Scheme, 522
- Scherz, Paul, 648
- Schiele, Egon, 217
- Schlegel, Andreas, 498, 571
- Schmidt, Karsten (a k a toxi), 4, 518
- Schoenerwissen/OfCD, 562
- Schöffner, Nicolas, 633
- Schumacher, Michael, 582
- Schwartz, Lillian, 315
- Scientific American, 461, 463
- Scratch, 680
- Screen Series (Snibbe), 549
- Scriptographer* (Lehni, Franke), 270–273, 683
- Seawright, James, 633
- sed, 684
- Semiconductor, 390–393, 646
- Sessions, Roger, 580
- Sester, Marie, 549
- Shannon, Claude, 669
- Shape of Song* (Wattenberg), 160–163
- Shaw, Jeffrey, 333
- Shiffman, Daniel, 6
- Shockwave Flash (SWF), 158, 565
- Short Messaging Service (SMS), 617, 619, 621
- SHRDLU, 101
- sh/tcsh, 515, 684
- Shulgin, Alexi, 563–564
- Silicon Graphics, 529, 537
- Simon, John F. Jr., 413, 565
- SimpleTEXT*, 618
- Sims, Karl, 295
- Sinclair Spectrum, 264
- Singer, Eric, 554
- Sketchpad, 217
- SketchUp, 538
- Slacker*, 383
- Slimbach, Robert, 112
- Smalltalk, 685
- Smith, Laura, 275
- Snake, 618
- Snibbe, Scott, 413, 549
- Social Mobiles (SoMo), 634
- Sodaconstructor* (Burton), 262–265, 413, 499
- Soda Creative Ltd., 263–264
- SoftVNS, 554
- Solidworks, 537
- Sommerer, Christa, 549
- Sonami, Laetitia, 582
- Sonic Inc., 392
- Sony, 634
- Sony Ericsson, 625
- Sorenson, 388
- Sorting Daemon (Rokeby), 548, 554
- Sound Films, 392

- Spark Fun Electronics, 640
 SQL (Structured Query Language), 685
 Srivastava, Muskan, 5
Standards and Double Standards (Lozano-Hemmer), 547–548
 Star Wars, 315
 Strausfeld, Lisa, 327
 Stedelijk Museum, 218
 Stehura, John, 315
 STEIM (Studio for Electro-Instrumental Music), 554
 Steinkamp, Jennifer, 387–388
 Stipe, Michael, 379–380
 Stockhausen, Karlheinz, 580
 Stone, Carl, 582
Stop Motion Studies (Crawford), 316
 Studies in Perception I, (Knowlton, Harmon), 604
Substrate (Tarbell), 6, 154, 156–159
 Sudol, Jeremi, 507
Suicide Box, 548, 554
 Sun Java Wireless Toolkit, 625
 Sun Microsystems, 521, 537, 625, 682
 SuperCollider, 571, 592, 685
 Sutherland, Ivan, 217
 SVG (Scalable Vector Graphics), 77, 520, 606, 624
 Symbian, 625
 Synergenix, 625
- Tale of Tales, 274–277
Talmud Project (Small), 327
Takeluma (Cho), 327
 Takis, 633
 Tarbell, Jared, 6, 155–156, 606
 Tangible Media Group (TMG), 634
 TARGA, 368, 606, 702
 Tate Gallery, 218
 T|C Electronics Powercore, 587
 tcpdump, 568–569
 TCP/IP, 554, 569, 589
 Technics, 507
 Teddy (Igarashi), 538
Telephony (Thompson, Craighead), 618
 TeleNav, 619
 Teleo (Making Things), 642
 Tesla, Nikola, 579
 Text-to-speech (TTS), 516–517
They Rule (On et al.), 266–269
 Thomson, Jon, 618
 TIFF, 368, 507, 606, 608, 611, 702
- Toy Story*, 315
 Tmemu, 510–513
 Transmission Control Protocol (TCP), 569
Tron, 315
 Truax, Barry, 581
 TrueType, 111
 Tsai, Wen-Ying, 633
 TurboGears, 684
 Turkle, Sherry, 5
Turux (Lia, Dextro), 316
Type, Tap, Write (Maeda), 333
 Tzara, Tristan, 150
- Überorgan* (Hawkinson), 633
 Unicode, 432, 665–668
 University of California Berkeley, 589
 Los Angeles (UCLA), xxi, 4, 5, 574
 San Diego (UCSD), 549
 University of Cincinnati (UC), xxiii
 University of Genoa, 554
 UNIX, 227, 435, 517, 569, 645
 U.S. Army Ballistic Missile Research Laboratories, 603
 USB, 556, 640–645, 701
 User Datagram Protocol (UDP), 554, 569, 589
 Ussachevsky, Vladimir, 580
 UTF-8, 665
 Utterback, Camille, 549
- Valicenti, Rick, 605
 van Blokland, Erik, 169–170
 van Blokland, Petr, 170
 VanDerBeek, Stan, 315
 Vanderlans, Rudy, 605
 van Rossum, Just, 169
 Vaucanson's Duck, 461
Vehicles: Experiments in Synthetic Psychology (Braitenberg), 473
 Venice Biennale, 391
 Verschoren, Jan, 275
 “Video Games and Computer Holding Power” (Turtle), 5
Videoplace (Krueger), 547
 Visual Language Workshop (VLW), 327, 702
 Visual programming languages (VPL or VL), 679–680
 Vitiello, Stephen, 582
 VLW font format, 112, 702
 Vogel, Peter, 632, 633
 Von Ehr, Jim, 170
 Vonnegut, Kurt, 507
- von Neumann, John, 461
 Vorbis codec, 585
 Voxel, 527
 vvvv, 685
- Wacom, 383
Waking Life, 382–385, 413
 Walt Disney, 315, 379
 Wang, Ge, 592
 Warner Bros. Records, 379
 Wattenberg, Martin, 161–162, 606
 Watz, Marius, 374
 WAV, 585–586, 621, 623, 702
 Wayfinder Systems, 619
 Wegman, William 606
 Weizenbaum, Joseph, 101
 Whitney, James, 315
 Whitney, John, 315
 Whitney Museum of American Art, 516
 Wilhelm Imaging Research, 610
 Wilson, Mark, 152, 217, 604
 Winograd, Terry, 101
 Wiring, 521, 633, 640, 641, 645–646, 648–649, 685
 Wright, Frank Lloyd, 333
 Wrongbrowser (Jodi), 566
 Wolfram, Steven, 461, 463–464, 467, 475
 Wolfenstein 3D, 525
 Wong, Andy, 507
 Wong, Yin Yin, 327
- Xenakis, Iannis, 581
 Xerox Palo Alto Research Center (PARC), 3, 205
 Xerox, 507
 xHTML Mobile, 624
 XML, 421, 427–428, 520, 549, 621, 624, 702
- Yamaha Digital Mixing Engine (DME), 516
Yellow Arrow, 618
 Youngblood, Gene, 388
- Ziggurat (font), 112
 Zooming user interface (ZUI), 435