
Contents



Preface	xv
Acknowledgements	xxi
About the Author	xxiii
Chapter 1: Essentials	1
1.1 The canvas Element	1
1.1.1 Canvas Element Size vs. Drawing Surface Size	5
1.1.2 The Canvas API	7
1.2 Canvas Contexts	8
1.2.1 The 2d Context	8
1.2.1.1 The WebGL 3d Context	11
1.2.2 Saving and Restoring Canvas State	11
1.3 Canonical Examples in This Book	12
1.4 Getting Started	14
1.4.1 Specifications	14
1.4.2 Browsers	15
1.4.3 Consoles and Debuggers	16
1.4.4 Performance	18
1.4.4.1 Profiles and Timelines	19
1.4.4.2 jsPerf	20
1.5 Fundamental Drawing Operations	22
1.6 Event Handling	26
1.6.1 Mouse Events	26
1.6.1.1 Translating Mouse Coordinates to Canvas Coordinates	26
1.6.2 Keyboard Events	31
1.6.3 Touch Events	33
1.7 Saving and Restoring the Drawing Surface	33
1.8 Using HTML Elements in a Canvas	36
1.8.1 Invisible HTML Elements	41
1.9 Printing a Canvas	46

1.10	Offscreen Canvases	51
1.11	A Brief Math Primer	53
1.11.1	Solving Algebraic Equations	54
1.11.2	Trigonometry	54
1.11.2.1	Angles: Degrees and Radians	54
1.11.2.2	Sine, Cosine, and Tangent	55
1.11.3	Vectors	56
1.11.3.1	Vector Magnitude	57
1.11.3.2	Unit Vectors	58
1.11.3.3	Adding and Subtracting Vectors	59
1.11.3.4	The Dot Product of Two Vectors	61
1.11.4	Deriving Equations from Units of Measure	62
1.12	Conclusion	64
Chapter 2:	Drawing	67
2.1	The Coordinate System	69
2.2	The Drawing Model	70
2.3	Drawing Rectangles	72
2.4	Colors and Transparency	74
2.5	Gradients and Patterns	78
2.5.1	Gradients	78
2.5.1.1	Linear Gradients	78
2.5.1.2	Radial Gradients	80
2.5.2	Patterns	81
2.6	Shadows	85
2.6.1	Inset Shadows	87
2.7	Paths, Stroking, and Filling	90
2.7.1	Paths and Subpaths	95
2.7.1.1	The Nonzero Winding Rule for Filling Paths	96
2.7.2	Cutouts	97
2.7.2.1	Cutout Shapes	100
2.8	Lines	105
2.8.1	Lines and Pixel Boundaries	106
2.8.2	Drawing a Grid	107
2.8.3	Drawing Axes	109
2.8.4	Rubberband Lines	112

2.8.5	Drawing Dashed Lines	119
2.8.6	Drawing Dashed Lines by Extending CanvasRenderingContext2D	120
2.8.7	Line Caps and Joins	123
2.9	Arcs and Circles	126
2.9.1	The arc() Method	126
2.9.2	Rubberband Circles	128
2.9.3	The arcTo() Method	129
2.9.4	Dials and Gauges	132
2.10	Bézier Curves	139
2.10.1	Quadratic Curves	139
2.10.2	Cubic Curves	143
2.11	Polygons	146
2.11.1	Polygon Objects	149
2.12	Advanced Path Manipulation	152
2.12.1	Dragging Polygons	153
2.12.2	Editing Bézier Curves	160
2.12.3	Scrolling Paths into View	171
2.13	Transformations	172
2.13.1	Translating, Scaling, and Rotating	173
2.13.1.1	Mirroring	175
2.13.2	Custom Transformations	176
2.13.2.1	Algebraic Equations for Transformations	177
2.13.2.2	Using transform() and setTransform()	178
2.13.2.3	Translating, Rotating, and Scaling with transform() and setTransform()	179
2.13.2.4	Shear	181
2.14	Compositing	183
2.14.1	The Compositing Controversy	188
2.15	The Clipping Region	189
2.15.1	Erasing with the Clipping Region	189
2.15.2	Telescoping with the Clipping Region	196
2.16	Conclusion	200

Chapter 3: Text	203
3.1 Stroking and Filling Text	204
3.2 Setting Font Properties	209
3.3 Positioning Text	212
3.3.1 Horizontal and Vertical Positioning	212
3.3.2 Centering Text	216
3.3.3 Measuring Text	217
3.3.4 Labeling Axes	219
3.3.5 Labeling Dials	223
3.3.6 Drawing Text around an Arc	225
3.4 Implementing Text Controls	227
3.4.1 A Text Cursor	227
3.4.1.1 Erasing	230
3.4.1.2 Blinking	232
3.4.2 Editing a Line of Text in a Canvas	234
3.4.3 Paragraphs	240
3.4.3.1 Creating and Initializing a Paragraph	244
3.4.3.2 Positioning the Text Cursor in Response to Mouse Clicks	244
3.4.3.3 Inserting Text	245
3.4.3.4 New Lines	246
3.4.3.5 Backspace	247
3.5 Conclusion	254
Chapter 4: Images and Video	255
4.1 Drawing Images	256
4.1.1 Drawing an Image into a Canvas	257
4.1.2 The drawImage() Method	259
4.2 Scaling Images	261
4.2.1 Drawing Images outside Canvas Boundaries	262
4.3 Drawing a Canvas into a Canvas	268
4.4 Offscreen Canvases	272
4.5 Manipulating Images	276
4.5.1 Accessing Image Data	276
4.5.1.1 ImageData Objects	281

4.5.1.2	Image Data Partial Rendering: <code>putImageData</code> 's Dirty Rectangle	282
4.5.2	Modifying Image Data	285
4.5.2.1	Creating <code>ImageData</code> Objects with <code>createImageData()</code>	287
4.5.2.1.1	The Image Data Array	288
4.5.2.2	Image Data Looping Strategies	294
4.5.2.3	Filtering Images	295
4.5.2.4	Device Pixels vs. CSS Pixels, Redux	297
4.5.2.5	Image Processing Web Workers	301
4.6	Clipping Images	304
4.7	Animating Images	308
4.7.1	Animating with an Offscreen Canvas	311
4.8	Security	314
4.9	Performance	315
4.9.1	<code>drawImage(HTMLImage)</code> vs. <code>drawImage(HTMLCanvas)</code> vs. <code>putImageData()</code>	316
4.9.2	Drawing a Canvas vs. Drawing an Image, into a Canvas; Scaled vs. Unscaled	318
4.9.3	Looping over Image Data	319
4.9.3.1	Avoid accessing object properties in the loop: Store properties in local variables instead	319
4.9.3.2	Loop over every pixel, not over every pixel value	322
4.9.3.3	Looping backwards and bit-shifting are crap shoots	322
4.9.3.4	Don't call <code>getImageData()</code> repeatedly for small amounts of data	323
4.10	A Magnifying Glass	323
4.10.1	Using an Offscreen Canvas	327
4.10.2	Accepting Dropped Images from the File System	328
4.11	Video Processing	330
4.11.1	Video Formats	331
4.11.1.1	Converting Formats	332
4.11.2	Playing Video in a Canvas	333
4.11.3	Processing Videos	336
4.12	Conclusion	340

Chapter 5: Animation	341
5.1 The Animation Loop	342
5.1.1 The requestAnimationFrame() method: Letting the Browser Set the Frame Rate	345
5.1.1.1 Firefox	347
5.1.1.2 Chrome	348
5.1.2 Internet Explorer	350
5.1.3 A Portable Animation Loop	350
5.2 Calculating Frame Rates	360
5.3 Scheduling Tasks at Alternate Frame Rates	361
5.4 Restoring the Background	362
5.4.1 Clipping	363
5.4.2 Blitting	365
5.5 Double Buffering	366
5.6 Time-Based Motion	369
5.7 Scrolling the Background	372
5.8 Parallax	379
5.9 User Gestures	385
5.10 Timed Animations	387
5.10.1 Stopwatches	387
5.10.2 Animation Timers	391
5.11 Animation Best Practices	392
5.12 Conclusion	393
Chapter 6: Sprites	395
6.1 Sprites Overview	396
6.2 Painters	400
6.2.1 Stroke and Fill Painters	400
6.2.2 Image Painters	406
6.2.3 Sprite Sheet Painters	408
6.3 Sprite Behaviors	413
6.3.1 Combining Behaviors	414
6.3.2 Timed Behaviors	418
6.4 Sprite Animators	419
6.5 A Sprite-Based Animation Loop	426
6.6 Conclusion	427

Chapter 7: Physics	429
7.1 Gravity	430
7.1.1 Falling	430
7.1.2 Projectile Trajectories	434
7.1.3 Pendulums	447
7.2 Warping Time	452
7.3 Time-Warp Functions	458
7.4 Warping Motion	460
7.4.1 Linear Motion: No Acceleration	463
7.4.2 Ease In: Gradually Accelerate	465
7.4.3 Ease Out: Gradually Decelerate	467
7.4.4 Ease In, then Ease Out	470
7.4.5 Elasticity and Bouncing	471
7.5 Warping Animation	475
7.6 Conclusion	484
Chapter 8: Collision Detection	485
8.1 Bounding Areas	485
8.1.1 Rectangular Bounding Areas	486
8.1.2 Circular Bounding Areas	487
8.2 Bouncing Off Walls	490
8.3 Ray Casting	492
8.3.1 Fine-tuning	496
8.4 The Separating Axis Theorem (SAT) and Minimum Translation Vector (MTV)	497
8.4.1 Detecting Collisions with the SAT	497
8.4.1.1 Projection Axes	502
8.4.1.2 Projections	505
8.4.1.3 Shapes and Polygons	506
8.4.1.4 Collisions Between Polygons	513
8.4.1.5 Circles	518
8.4.1.6 Images and Sprites	523
8.4.2 Reacting to Collisions with the Minimum Translation Vector .	528
8.4.2.1 The MTV	528
8.4.2.2 Sticking	533

8.4.2.3	Bouncing	539
8.5	Conclusion	543
Chapter 9: Game Development		545
9.1	A Game Engine	546
9.1.1	The Game Loop	547
9.1.1.1	Pause	553
9.1.1.2	Time-Based Motion	555
9.1.2	Loading Images	556
9.1.3	Multitrack Sound	559
9.1.4	Keyboard Events	560
9.1.5	High Scores	562
9.1.6	The Game Engine Listing	563
9.2	The Ungame	574
9.2.1	The Ungame's HTML	575
9.2.2	The Ungame's Game Loop	578
9.2.3	Loading the Ungame	581
9.2.4	Pausing	583
9.2.4.1	Auto-Pause	585
9.2.5	Key Listeners	586
9.2.6	Game Over and High Scores	587
9.3	A Pinball Game	591
9.3.1	The Game Loop	592
9.3.2	The Ball	595
9.3.3	Gravity and Friction	596
9.3.4	Flipper Motion	597
9.3.5	Handling Keyboard Events	599
9.3.6	Collision Detection	603
9.3.6.1	SAT Collision Detection	603
9.3.6.2	The Dome	611
9.3.6.3	Flipper Collision Detection	613
9.4	Conclusion	616
Chapter 10: Custom Controls		617
10.1	Rounded Rectangles	619
10.2	Progress Bars	627
10.3	Sliders	633

10.4 An Image Panner	645
10.5 Conclusion	657
Chapter 11: Mobile	659
11.1 The Mobile Viewport	661
11.1.1 The viewport Metatag	663
11.2 Media Queries	668
11.2.1 Media Queries and CSS	668
11.2.2 Reacting to Media Changes with JavaScript	670
11.3 Touch Events	673
11.3.1 Touch Event Objects	674
11.3.2 Touch Lists	674
11.3.3 Touch Objects	675
11.3.4 Supporting Both Touch and Mouse Events	676
11.3.5 Pinch and Zoom	677
11.4 iOS5	679
11.4.1 Application Icons and Startup Images	680
11.4.2 Media Queries for iOS5 Application Icons and Startup Images	681
11.4.3 Fullscreen with No Browser Chrome	682
11.4.4 Application Status Bar	683
11.5 A Virtual Keyboard	684
11.5.1 A Canvas-Based Keyboard Implementation	685
11.5.1.1 The Keys	691
11.5.1.2 The Keyboard	695
11.6 Conclusion	703
Index	705