

Index

A

accumulation buffer, 376, 378, 394–408
 clearing, 32, 379
depth-of-field effect, use for, 402–406
examples of use, 394
full range for best results, use, 600
motion blur, use for, 402
sample program with depth-of-field effect, 404
sample program with full-scene antialiasing, 397
scene antialiasing, use for, 396
AGL, 566
 aglChoosePixelFormat(), 566, 569
 aglCopyContext(), 567, 569
 aglCreateAGLPixmap(), 567, 569
 aglCreateContext(), 567, 569
 aglDestroyAGLPixmap(), 568, 569
 aglDestroyContext(), 567, 569
 aglGetConfig(), 566, 569
 aglGetCurrentContext(), 567, 569
 aglGetCurrentDrawable(), 567, 569
 aglGetError(), 568, 569
 aglListPixelFormats(), 566, 569
 aglMakeCurrent(), 567, 569
 aglQueryVersion(), 566, 568
 aglSetOptions(), 567, 569
 aglSwapBuffers(), 568, 569
 aglUpdateCurrent(), 568, 569
 aglUseFont(), 568, 569
airbrushing, 528
Akeley, Kurt, 394
aliasing, See antialiasing
alpha, 214
 destination alpha, 236
 material properties, 197
 texture image data type, 354
alpha blending, See blending
alpha test, 384
 querying current values, 384
 rendering pipeline stage, 14, 533
ambient

contribution to lighting equation, 207
global light, 193, 206
light, 173, 174, 182
material properties, 175, 197
animation, 20–24, 600
antialiasing, 226–239
 accumulation buffer used for, 395–401
 characters (by masking), 512
 characters (by texturing), 523
 color-index mode, 232
 coverage values, 227
 enabling for points or lines, 228
 enabling for polygons, 236
 lines, 226, 228–235
 lines (by texturing), 523
 points, 228–235, 514
 polygons, 235
 RGBA mode, 229
 sample program in color-index mode, 232
 sample program in RGBA mode, 229
 sample program of filled polygons, 236
 scene, with the accumulation buffer, 396
architectural applications
 orthographic parallel projection, use of, 124
arcs, 428
aspect ratio
 perspective projection, 122
 viewport transformation, 126
atmospheric effects, See fog
attenuation of light, 183–184
attribute groups, 78–81
 client, 78
 list of, 537–559
 performance tips, 602
 server, 78
 stack depth, obtaining, 79
 stacks, 78
auxiliary buffers, 377, 380

B

back-facing polygons, 56
culling, 57
material property, specifying, 196
two-sided lighting, 194
background, 29–32
color, 29
drawing a fixed, 382, 523
background processing, 584
backward compatibility
 tessellation, 426
 versions, 503
basis functions, 439, 440
Bernstein
 basis, 439
 polynomial, 443
Bézier
 basis, 439, 440
 curve, 443
 sample program using mesh for surface, 451
sample program which draws curve, 441
sample program which draws surface, 448
surface, 446
billboarding, 219, 385
bitmaps, 278–284
 display lists cache bitmap data, 257
 distorting, 509
 drawing, 283
 feedback mode, 493
 fonts, used for, 279, 286
 imaging pipeline operations, 297
 ordering of data in, 281
 origin of, 283
 sample program, 280
 sample program that creates a font, 287
 size of, 281
bitplanes, 156, 374
 displayable colors, number of, 158
blending, 214–223, 392
 antialiasing polygons, 235
 coverage calculations for antialiasing, 227
 destination alpha, 236
 enabling, 216
 enabling for antialiasing, 229

factors (source and destination), 215
images, 514
ordering polygons before drawing, 222
rendering pipeline stage, 14, 533
sample program for three-dimensional, 223
sample program with blended polygons, 220
texture function, 356
three dimensions, in, 222
uses of, 217
buffer, See framebuffer

C

C programming language, 8
CAD/CAM, See computer-aided design
camera analogy, 94–95
 environment mapping, 370
 viewport transformations, 125
capping, See computational solid geometry
characters
 antialiasing, 523
circles, 428
clearing the framebuffer, 29–32, 378–379
 affected by scissoring, dithering, and masking, 379, 533
 performance tips, 603
client-server, See networked operation
clip coordinates, 96, 137
 feedback mode, 493
clipping, 125
 interference regions found using clipping planes, 519
 overview, 92
 primitives in rendering pipeline, 12, 531
 viewing volume, 121
clipping planes
 additional clipping planes, 96, 136–139
 depth-buffer resolution, effect on, 600
 far, 121–125, 129
 near, 121–125, 129
 querying number of additional, 137
 sample program with additional clipping planes, 138
color
 alpha values, 214
 background, 30

-
- cube showing blended RGB values, 155
 current raster color, 285
 human perception, 153
 RGBA values for, 33, 154
 specifying, 32
 specifying for tessellation, 415
 specifying in color-index mode, 164
 specifying in RGBA mode, 163
 color buffer, 154, 156, 374, 376, 377
 clearing, 32
 masking, 381
 color map, 154, 159
 loading for antialiasing, 232
 loading for smooth shading, 167
 loading, using GLUT, 583
 size of, 160
 color-index mode, 159–161
 changing between RGBA mode and, 162
 choosing between RGBA mode and, 161
 coverage calculations for antialiasing, 227
 dithering, 393
 layering with writemasks, 381
 lighting, 209–211
 lighting calculations in, 210
 texturing limitations, 321, 329
 vertex arrays, specifying values with, 68
 command syntax, 7–9
 compositing images, 219
 compositing transformations, 139–146
 computational solid geometry, 421
 capping, 390
 difference of several contours, 421
 interference regions, 518
 intersection of two contours, 421
 union of several contours, 421
Computer Graphics: Principles and Practice, xxi, 157, 593
 computer-aided design
 orthographic parallel projection, use of, 124
 concave polygons
 GLU tessellation, 410
 stencil buffer, drawing with the, 516
 cones, 428, 584
 improving rendering of, 525
 constant attenuation, 184
 contours, 365
 control points, 438, 442, 446, 455
 convex polygons, 38
 Conway, John, 526
 coordinate systems
 grand, fixed, 106, 115, 140
 local, 106, 115, 140, 144
 simple 2D, 35–36
 coordinates
 See clip coordinates, depth coordinates, eye coordinates,
 homogeneous coordinates, normalized device
 coordinates, object coordinates, q texture
 coordinates, texture coordinates, w coordinates, or
 window coordinates
 coverage, pixel, 227
 Coxeter, H. S. M., 593
 cross product, 118, 589
 CSG, See computational solid geometry
 culling, 56–57
 enabling, 57
 rendering pipeline stage, 12, 532
 curves and curved surfaces, 40
 see also evaluators or NURBS
Curves and Surfaces for Computer-Aided Geometric Design, 439
 cylinders, 428
- D**
- data types
 RGBA color conversion, 163
 special OpenGL, 8
 texture data, 328
 warning about data type conversions, 601
 decals, 385, 515
 polygon offset used for, 247
 texture function, 356
 depth buffer, 172, 376, 377
 also see hidden-surface removal
 background, using masking for a common, 382
 blending, use for three-dimensional, 222
 clearing, 32, 172, 379
 decals, for, 515

Dirichlet domains, for, 525
drawing static backgrounds, 523
masking, 381
near frustum plane effect on resolution, 600
pixel data, 295, 303
depth coordinates, 97, 128
perspective division, 128
picking use, 485
polygon offset, 247–250
rendering pipeline stage for depth-range operations, 12, 532
sample program with picking, 486
selection hit records, 474
depth test, 391
also see depth buffer
rendering pipeline stage, 14, 533
depth-cuing, See fog
depth-of-field effect, 402–406
 sample program, 404
destination factor, See blending
diffuse
 contribution to lighting equation, 207
 light, 174, 182
 material properties, 175, 197
directional light source, 182
Dirichlet domains, 524
disks, 428
display lists, 29, 253
 changing mode settings, 275
 compiling, 262
 creating, 259
 deleting, 267
 disadvantages, 259, 265
 editing limitations, 256
 error handling, 261, 600
 executing, 259, 265
 executing multiple, 267
 font creation, 268, 285
 hierarchical, 265
 immediate mode, mixing with, 265
 indices for, obtaining, 262
 naming, 262
 nesting, 265
 nesting limit, querying, 266
 networked operation, 264
performance tips, 257, 602
querying use of an index, 267
rendering pipeline stage, 11
sample program creating a font, 269
sample program for creating, 253, 259
sharing among rendering contexts, 563, 575
state variables saved and restored, 274
tessellation, use with, 426
uses for, 257, 275
vertex-array data, 264
 what can be stored in, 263
distorted images, 509
 texture images, 359
dithering, 158–159, 392, 600
 and clearing, 379
 rendering pipeline stage, 14, 533
dot product
 lighting calculations, use in, 207
double-buffering, 22–24
 automatic glFlush(), 35
 changing between single-buffering and, 162
 object selection using the back buffer, 508
 querying its presence, 377
 sample program, 24
drawing
 clearing the window, 30
 forcing completion of, 33
 icosahedron, 83
 points, 42
 polygons, 42, 55
 preparing for, 29
 rectangles, 40
 spheres, cylinders, and disks, 428–436
drawing pixel data, See pixel data
Duff, Tom, 219

E

edge flags, 62–63
 tessellated polygons generate, 414
 vertex arrays, specifying values with, 68
emission, 175, 198, 206
enabling
 alpha test, 384

antialiasing of points or lines, 228
antialiasing polygons, 236
blending, 216
color material properties mode, 201
culling, 57
depth test, 391
dithering, 159, 392
evaluators, 443, 447
fog, 240
lighting, 195
line stippling, 51
logical operations, 393
normal vectors for evaluated surfaces, automatic generation of, 447, 455
polygon offset, 247
polygon stippling, 58
stencil test, 386
texture coordinate generation, 369
texturing, 322, 326
unit length normal vectors ensured, 65
endianness, 300
environment mapping, 369
error handling, 501–503
 error string description, 503
 recommended usage, 600
evaluators, 440–454
 basis functions, 439, 443
 evenly spaced values, 445, 449
 one-dimensional, 440
 rendering pipeline stage, 11
sample program using mesh for 2D Bézier surface, 451
sample program which draws 1D Bézier curve, 441
sample program which draws 2D Bézier surface, 448
sample program which generates texture coordinates, 452
tessellation usage, 602
texture coordinates, generating, 452
two-dimensional, 446, 447
event management, using GLUT, 19
example programs, See programs
extensions
 vendor-specific, 505
eye coordinates, 96, 137
 texture coordinate generation, 364, 369

F

fade effect, 507
Farin, Gerald E., 439
feedback, 491–498
 array contents, 497
 pass-through markers, 494
 querying current rendering mode, 472
 returned data, 493
 sample program, 495
 steps to perform, 492
 tessellation, obtaining vertex data after, 426
Feiner, Steven K., xxi, 593
field of view, 100
 calculate, using trigonometry to, 130
filtering, 344–346
 mipmapped textures, 338–344, 346
 texture border colors, 361
flat shading, 165
flight simulation
 fog, use of, 239
flushing, 33, 600
fog, 239–247
 blending factors, 243
 color-index mode, 244
 density, 244
 enabling, 240
 equations, 243
 hints, 240
 RGBA mode, 244
 sample program in color-index mode, 245
 sample program in RGBA mode, 240
Foley, James D., xxi, 157, 593
fonts, 285–289
 antialiased characters (by masking), 512
 antialiased characters (by texturing), 523
 bitmapped, 286
 creating with display lists, 268
 drawing, 284
 drawing as bitmaps, 279
 multi-byte, 286
 same program, 287
 sample program using multiple display lists, 269
 X fonts, using, 564
Foran, Jim, 372

foreshortening, perspective, 120
fragments, 156, 374
alpha test, 384
blending, 215
depth test, 391
rendering pipeline operations, 13, 533
scissor test, 383
tests, 383–393
texture functions, 356
framebuffer, 156, 375
capacity per pixel, 376
clearing, 378–379
copying pixel data within, 290, 295, 296
enabling for reading, 380
enabling for writing, 380
minimum configuration with the X Window System, 376
querying color resolution, 156
reading pixel data from, 290, 292
writing pixel data to, 290, 294
front-facing polygons, 56
specifying material property for, 196
two-sided lighting, 194
frustum, 120
ftp (file-transfer protocol) site
GLUT source code, xxii
GLX specification, 562
OpenGL Programming Guide, xxii
Fundamentals of Computer Aided Geometric Design, 439
Fundamentals of Three-Dimensional Computer Graphics, 318

G

Game of Life, 526
gamma correction, 157
Gardner, Martin, 526
geometric primitives, 37–48, 530–532
 performance when specifying, 603
 rendering pipeline stage, 12
geosciences
 use of texturing in applications, 364
giraffe, 160

glAccum(), 395
glAlphaFunc(), 384
glAreTexturesResident(), 352
glArrayElement(), 71
 legal between glBegin() and glEnd(), 46
Glassner, Andrew S., xxi
glBegin(), 42, 43, 414
 restrictions, 45
glBindTexture(), 326, 348
glBitmap(), 279, 283
 feedback mode, 493
 fonts, used for, 286
 imaging pipeline operations, 297
 pixel-storage modes effect, 299
glBlendFunc(), 216
glCallList(), 256, 259, 265
 legal between glBegin() and glEnd(), 46
glCallLists(), 268
 fonts, use for, 285
 legal between glBegin() and glEnd(), 46
 sample program, 287
glClear(), 30, 31, 379, 533
 depth buffer, clearing the, 172
glClearAccum(), 32, 379
glClearColor(), 30, 31, 379
glClearDepth(), 31, 379
glClearIndex(), 32, 165, 379
 fog, use with, 245
glClearStencil(), 32, 379
glClipPlane(), 137
glColor*(), 33, 163
 legal between glBegin() and glEnd(), 46
glColorMask(), 379, 381
glColorMaterial(), 201
 performance tips, 602
glColorPointer(), 68
glCopyPixels(), 290, 295
 alternative uses, 527
 dithering, turn off, 600
 feedback mode, 493
 glReadBuffer() effect, 380
 imaging pipeline operations, 296
 pixel-transfer modes effect, 302

glCopyTexImage1D(), **336**
 glReadBuffer() effect, **380**
 pixel-transfer modes effect, **302**
glCopyTexImage2D(), **329**
 glReadBuffer() effect, **380**
 pixel-transfer modes effect, **302**
glCopyTexSubImage1D(), **337**, **337**
 glReadBuffer() effect, **380**
 pixel-transfer modes effect, **302**
glCopyTexSubImage2D(), **335**
 glReadBuffer() effect, **380**
 pixel-transfer modes effect, **302**
glCullFace(), **57**
glDeleteLists(), **267**, **286**
glDeleteTextures(), **351**
glDepthFunc(), **391**
glDepthMask(), **381**
 blending opaque and translucent objects, **223**
glDepthRange(), **128**
 gluUnProject(), relationship to, **147**
glDisable(), **10**, **48**
glDisableClientState(), **68**
glDrawArrays(), **74**
glDrawBuffer(), **295**, **380**
glDrawElements(), **72**
glDrawPixels(), **290**, **294**, **387**, **524**
 alternative uses, **527**
 feedback mode, **493**
 pixel-storage modes effect, **299**
 pixel-transfer modes effect, **302**
glEdgeFlag*(), **63**
 legal between glBegin() and glEnd(), **46**
glEdgeFlagPointer(), **68**
glEnable(), **48**, **178**
 also see enabling
glEnableClientState(), **46**, **67**
glEnd(), **42**, **43**, **414**
 restrictions, **45**
glEndList(), **256**, **259**, **263**
glEvalCoord*(), **445**, **447**
 legal between glBegin() and glEnd(), **46**
 used instead of glVertex*(), **440**, **443**
glEvalMesh*(), **445**, **449**
glEvalPoint*()
 legal between glBegin() and glEnd(), **46**
glFeedbackBuffer(), **492**
 glRenderMode(), use with, **472**
glFinish(), **35**
glFlush(), **34**, **35**, **600**
glFog*(), **243**
glFrontFace(), **56**
glFrustum(), **101**, **121**, **121**, **533**
glGenLists(), **256**, **262**
 fonts, use for, **286**
glGenTextures(), **326**, **347**
glGetBooleanv(), **10**, **49**, **537**
 double-buffering support, querying, **377**
 stereo support, querying, **377**
glGetClipPlane(), **536**
glGetDoublev(), **10**, **49**, **537**
glGetError(), **10**, **502**, **536**
glGetFloatv(), **10**, **49**, **537**
 line width attributes, obtaining, **51**
 point size attributes, obtaining, **50**
glGetIntegerv(), **10**, **49**, **537**
 alpha test information, obtaining, **384**
 attribute stack depth, obtaining, **79**
 clipping planes, obtaining number of additional, **137**
 color resolution, obtaining, **156**
 display list nesting limit, obtaining, **266**
 matrix stack depth, obtaining, **135**
 maximum texture size, obtaining, **330**
 name stack depth, obtaining, **473**
 pixel map information, obtaining, **304**
 rendering mode, obtaining current, **472**
 stencil-related values, obtaining, **386**
glGetLight*(), **10**, **536**
glGetMap*(), **536**
glGetMaterial*(), **536**
glGetPixelMap*(), **536**
glGetPointerv(), **10**, **49**, **537**
glGetPolygonStipple(), **10**, **536**
glGetString(), **503**, **536**
glGetTexEnv*(), **536**
glGetTexGen*(), **536**
glGetTexImage(), **536**

pixel-storage modes effect, 299
pixel-transfer modes effect, 302
`glGetTexLevelParameter*`(*), 331, 536*
`glGetTexParameter*`(*, 536*
 texture residency, obtaining, 351
`glHint()`, 228
 fog use, 240
 texture use, 326
`glIndex*`(*, 164*
 fog, use with, 245
 legal between `glBegin()` and `glEnd()`, 46
`glIndexMask()`, 379, 381
`glIndexPointer()`, 68
`glInitNames()`, 471, 472, 473
`glInterleavedArrays()`, 76
`glIsEnabled()`, 10, 48, 537
`glIsList()`, 267
`glIsTexture()`, 347
`glLight*`(*, 178, 180, 181, 186*
`glLightModel*`(*, 193*
`glLineStipple()`, 51
`glLineWidth()`, 50
`glListBase()`, 267
 fonts, use for, 286
 sample program, 287
`glLoadIdentity()`, 101, 103, 112, 533
 performance tips, 602
 viewing transformations, use before, 99
`glLoadMatrix*`(*, 102, 104, 104, 533*
`glLoadName()`, 472, 474
`glLogicOp()`, 394
`glMap*`(*, 442, 443, 446*
`glMapGrid*`(*, 445, 449*
`glMaterial*`(*, 179, 196*
 legal between `glBegin()` and `glEnd()`, 46
 performance tips, 602
`glMatrixMode()`, 101, 103
 use with matrix stacks, 133
`glMultMatrix*`(*, 102, 104, 533*
 performance tips, 602
`glNewList()`, 256, 259, 262
`glNormal*`(*, 64*
 legal between `glBegin()` and `glEnd()`, 46
`glNormalPointer()`, 68
`glOrtho()`, 124, 533
 picking matrix use, 479
`glPassThrough()`, 492, 494
`glPixelMap*`(*, 304*
`glPixelStore*`(*, 299*
 cannot be stored in display lists, 264
 polygon stippling, 58
 texture image data, effect on, 328, 329, 332, 335, 336
`glPixelTransfer*`(*, 302, 524*
 texture image data, effect on, 328, 329, 332, 335, 336
`glPixelZoom()`, 305, 509
`glPointSize()`, 50
`glPolygonMode()`, 56
 antialiasing, effect on, 235
 polygon offset, use with, 247
`glPolygonOffset()`, 248
`glPolygonStipple()`, 58
 pixel-storage modes effect, 299
`glPopAttrib()`, 10, 79, 274, 537
`glPopClientAttrib()`, 10, 81, 537
`glPopMatrix()`, 133, 143, 189, 274
 restore orientation of coordinate systems, 146
 selection, use with, 471
`glPopName()`, 472, 473
`glPrioritizeTextures()`, 353
`glPushAttrib()`, 10, 79, 274, 537
`glPushClientAttrib()`, 10, 81, 537
`glPushMatrix()`, 133, 143, 189, 274
 save orientation of coordinate systems, 146
 selection, use with, 471
`glPushName()`, 471, 472, 473
`glRasterPos*`(*, 279, 282*
 images, for positioning, 290
 selection hits, can cause, 474
`glReadBuffer()`, 295, 380
`glReadPixels()`, 290, 292
 `glReadBuffer()` effect, 380
 pixel-storage modes effect, 299
 pixel-transfer modes effect, 302
`glRect*`(*, 40*
`glRenderMode()`, 471, 472, 474, 492

-
- glRotate*(), **109, 140, 143, 533**
 - performance tips, **602**
 - glScale*(), **99, 110, 143, 533**
 - performance tips, **602**
 - glScissor(), **383**
 - glSelectBuffer(), **471, 472**
 - display lists, cannot be stored in, **264**
 - glShadeModel(), **165**
 - glStencilFunc(), **385**
 - glStencilMask(), **381**
 - glStencilOp(), **386**
 - glTexCoord*(), **326, 358**
 - legal between glBegin() and glEnd(), **46**
 - glTexCoordPointer(), **68**
 - glTexEnv*(), **326, 354**
 - glTexGen*(), **364**
 - environment mapping, **370**
 - glTexImage1D(), **335**
 - pixel-storage modes effect, **299**
 - pixel-transfer modes effect, **302**
 - glTexImage2D(), **326, 327**
 - pixel-storage modes effect, **299**
 - pixel-transfer modes effect, **302**
 - specifying mipmaps, **339**
 - glTexParameter*(), **326, 363**
 - specifying filtering methods, **345**
 - glTexSubImage1D(), **336**
 - pixel-storage modes effect, **299**
 - pixel-transfer modes effect, **302**
 - glTexSubImage2D(), **332**
 - pixel-storage modes effect, **299**
 - pixel-transfer modes effect, **302**
 - glTranslate*(), **108, 140, 143, 533**
 - performance tips, **602**
 - GLU, **2, 14, 410**
 - drawing spheres, cylinders, and disks, **428–436**
 - error string description, **503**
 - obsolete routines
 - gluBeginPolygon(), **427**
 - gluEndPolygon(), **427**
 - gluNextContour(), **427**
 - quadrics, **428–436**
 - tessellation, **39, 410–428**
 - version numbers, obtaining, **504**
 - gluBeginCurve(), **455, 464**
 - gluBeginSurface(), **455, 463**
 - gluBeginTrim(), **465**
 - gluCylinder(), **429, 431**
 - gluDeleteNurbsRenderer(), **460**
 - gluDeleteQuadric(), **429, 429**
 - gluDeleteTess(), **426, 427**
 - gluDisk(), **429, 432**
 - gluEndCurve(), **455, 464**
 - gluEndSurface(), **455, 463**
 - gluEndTrim(), **465**
 - gluErrorString(), **429, 462, 503**
 - polygon tessellation, **414**
 - gluGetNurbsProperty(), **461, 536**
 - gluGetString(), **505, 536**
 - gluGetTessProperty(), **422, 536**
 - gluLoadSamplingMatrices(), **461**
 - gluLookAt(), **97, 99, 116, 140**
 - gluNewNurbsRenderer(), **455, 459**
 - gluNewQuadric(), **428, 429**
 - gluNewTess(), **412, 427**
 - gluNurbsCallback(), **455, 462**
 - gluNurbsCurve(), **455, 464**
 - gluNurbsProperty(), **455, 460**
 - gluNurbsSurface(), **455, 463**
 - gluOrtho2D(), **125, 601**
 - resized windows, use with, **36**
 - gluPartialDisk(), **429, 432**
 - gluPerspective(), **101, 123, 140**
 - picking matrix use, **479**
 - gluPickMatrix(), **479**
 - gluProject(), **150**
 - gluPwlCurve(), **465**
 - gluQuadricCallback(), **429, 429**
 - gluQuadricDrawStyle(), **428, 430**
 - gluQuadricNormals(), **428, 430**
 - gluQuadricOrientation(), **428, 430**
 - gluQuadricTexture(), **429, 431**
 - gluScaleImage(), **329**
 - gluSphere(), **429, 431**

GLUT, **15**, 579–585
 basic functions, 16–20
 event management, 19
 glutCreateWindow(), 17, **581**
 glutDisplayFunc(), 17, **581**
 glutIdleFunc(), 20, **584**
 glutInit(), 16, **580**
 glutInitDisplayMode(), 16, **580**
 glutInitWindowSize(), 17, **581**
 glutKeyboardFunc(), 19, **582**
 glutMainLoop(), 17, **585**
 glutMotionFunc(), 19, **582**
 glutMouseFunc(), 19, **582**
 glutPostRedisplay(), 17, 256, **582**
 glutReshapeFunc(), 19, **582**
 simple example, 35
 glutSetColor(), 16, 165, 210, **583**
 smooth shading, use for, 167
 glutSolidCone(), **584**
 glutSolidCube(), 20, **583**
 glutSolidDodecahedron(), **584**
 glutSolidIcosahedron(), **584**
 glutSolidOctahedron(), **584**
 glutSolidSphere(), 20, **583**
 glutSolidTeapot(), **584**
 glutSolidTetrahedron(), **584**
 glutSolidTorus(), **583**
 glutSwapBuffers(), 23
 glutWireCone(), **584**
 glutWireCube(), 20, **583**
 glutWireDodecahedron(), **584**
 glutWireIcosahedron(), **584**
 glutWireOctahedron(), **584**
 glutWireSphere(), 20, 140, **583**
 glutWireTeapot(), **584**
 glutWireTetrahedron(), **584**
 glutWireTorus(), **583**
 sample program introducing GLUT, 18
 window management, 16, 35
gluTessBeginContour(), **423**
gluTessBeginPolygon(), **423**
gluTessCallback(), **412**, 423, 427
gluTessEndContour(), **423**
gluTessEndPolygon(), **423**
gluTessNormal(), 422, **422**, 426
gluTessProperty(), **417**, 423
gluTessVertex(), **423**, 427
gluUnProject(), **147**, 150
glVertex*(), **41**
 legal between glBegin() and glEnd(), 46
 using glEvalCoord*() instead, 440
glVertexPointer(), **46**, **68**
glViewport(), 102, **126**
 using with resized windows, 36
GLX, **14**, 562
 ftp site for GLX specification, 562
 glXChooseVisual(), 563, 604
 glXCopyContext(), 563
 glXCreateContext(), 563
 glXCreateGLXPixmap(), 563
 glXDestroyContext(), 563
 glXDestroyGLXPixmap(), 563
 glXGetClientString(), 562
 glXGetConfig(), 376, 563
 glXGetCurrentContext(), 563
 glXGetCurrentDisplay(), 563
 glXGetCurrentDrawable(), 563
 glXIsDirect(), 563
 glXMakeCurrent(), 563
 glXQueryExtension(), 562
 glXQueryExtensionsString(), 562
 glXQueryServerString(), 562
 glXQueryVersion(), 562
 glXSwapBuffers(), 23, 564
 glXUseXFont(), 564
 glXWaitGL(), 564
 performance tips, 603

`glXWaitX()`, **564**
performance tips, **603**
Gouraud shading, See smooth shading

H

Haeberli, Paul, **372, 394**
haze, See fog
header file, **15**
hidden-line removal, **521**
 polygon offset used for, **247**
hidden-surface removal, **171–173, 391**
hierarchical models, **132, 265**
 picking, **483–485**
highlights, See specular
hints, **228**
 fog, **240**
 perspective correction, **228, 326**
hits (selection), See selection (hit records)
holes in polygons, **38, 518**
homogeneous coordinates, **37, 594**
Hoschek, Josef, **439**
Hughes, John F., **xxi, 593**

sample code which draws an image, **294**
sample program which draws, copies, and zooms an
 image, **306**
scaling and rotating, **523**
sources of, **290**
superimposing, **515**
transposing, **528**
warping, **523**
imaging pipeline, See images (imaging pipeline)
immediate mode, **29, 252**
 display lists, mixing with, **265**
infinite light source, **182**
input events
 handling, using GLUT, **19**
intensity
 texture image data type, **354**
*Interactive Inspection of Solids: Cross-sections and
Interferences*, **518**
interference regions, **518**
interleaved arrays, **75**
interpolating
 color values and texture coordinates, **228, 357**
invariance
 of an OpenGL implementation, **600, 605**
Inventor, see Open Inventor

I

IBM OS/2 Presentation Manager to OpenGL Interface, see
 PGL
icosahedron, drawing, **83**
identity matrix, **99, 103, 112, 602**
illumination, See lighting
images, **278, 289–295**
 also see pixel data
 blending, **514**
 compositing, **215**
 distorted, **509**
imaging pipeline, **291, 296–308**
interpolating between, **514**
magnifying or reducing, **305**
nonrectangular, **219**
projecting, **523**

J

jaggies, **226**
jittering, **396, 401, 407**
 `accFrustum()` routine, **396**
 `accPerspective()` routine, **396**
sample code to jitter projection transformations, **397**
sample program with orthographic projection, **401**

K

Kilgard, Mark, **xxii, 15, 562, 579**
Korobkin, Carl, **372**

L

Lasser, Dieter, 439
layers, drawing, 511
Life, Game of, 526
light sources, 180–192
 ambient light, 174, 182
 contribution to lighting equation, 206
 diffuse light, 174, 182
 directional, 182
 display lists cache values, 258
 infinite light source, 182
 local light source, 182
 maximum number of sources, 178
 moving along with the viewpoint, 191
 moving light sources, 187–192
 multiple light sources, 186
 performance tips, 178
 positional, 182
 rendering pipeline stage, 12, 531
 RGBA values, 175
 sample program that moves the light source, 189
 specifying a light source, 178
 specular light, 174
 spotlights, 184–186
 stationary, 187
lighting
 also see light sources, material properties
 ambient light, 173
 approximation of the real world, 173
 attenuation, 183–184
 calculations in color-index mode, 210
 color-index mode, 209–211
 default values, using, 179
 display lists cache values, 258
 enabling, 178, 179
 enabling and disabling, 195
 equation that calculates lighting, 205
 global ambient light, 193, 206
 lighting model, 192–195
 lighting model, specifying a, 179
 rendering pipeline stage, 12, 531
 sample program introducing lighting, 176
 steps to perform, 176
 two-sided materials, 194
 viewer, local or infinite, 194

line segment, 38
linear attenuation, 184
lines, 38
 antialiasing, 228–235, 523
 connected closed loop, specifying, 43, 44
 connected strip, specifying, 43, 44
 feedback mode, 493
 querying line width, 51
 sample program with wide, stippled lines, 53
 specifying, 43, 44
 stippling, 51
 tessellated polygons decomposed into, 414
 width, 50
local light source, 182
logical operations
 rendering pipeline stage, 14, 533
 transposing images, using for, 528
lookup table, See color map
luminance, 292, 314
 pixel data formats for, 293, 298
 texture image data type, 354

M

magnifying images, 305
masking, 381
 antialiasing characters, 513
 layers, drawing, 511
 rendering pipeline stage, 14, 533
material properties, 179, 195–204
 ambient, 175, 197
 changing a single parameter with glColorMaterial(), 201
 changing material properties, 199
 diffuse, 175, 197
 display lists cache values, 258
 emission, 175, 198, 206
 enabling color material properties mode, 201
 performance when changing, 602
 rendering pipeline stage, 12, 531
 RGBA values, 176

-
- sample program which changes material properties, 199
 sample program which uses glColorMaterial(), 202
 shininess, 198
 specular, 175, 198
 two-sided lighting, 194
- matrix**
 also see matrix stack
 choosing which matrix is current, 103
 column-major ordering, 104
 current, 99
 danger of extensive changes, 600
 display lists cache matrix operations, 257
 identity, 99, 103, 112, 602
 loading, 104
 modelview, 96, 103
 multiplying matrices, 104
 NURBS, specifying for sampling, 461
 orthographic parallel projection, 598
 perspective projection, 598
 projection, 101, 103
 rotation, 596
 row-major ordering, 104
 scaling, 596
 texture, 371
 transformation pipeline, 96
 transformations of homogeneous coordinates, 594
 translation, 596
- matrix stack**, 132–136
 choosing which matrix stack is current, 133
 current matrix stack, 533
 modelview, 135
 popping, 133
 projection, 135
 pushing, 133
 querying stack depth, 135
 texture, 371
- Megahed, Abe**, 518
- Microsoft**
 Microsoft Win32, See Win32
 Microsoft Windows, 14
 Microsoft Windows 95, 574
 Microsoft Windows NT, xxii
- Microsoft Windows to OpenGL interface, See WGL
 mipmapping, 338–344
 minification filters, 346
 texture objects for mipmaps, 350
- mirroring objects, See scaling
 modeling transformations, 99, 104, 108–113
 camera analogy, 94
 connection to viewing transformations, 100
 example, 111
 rotation, 109
 rotation matrix, 596
 sample program, 112
 scaling, 110
 scaling matrix, 596
 translation, 108
 translation matrix, 596
- models**
 rendering wireframe and solid, 20, 583
- modelview matrix**, 96, 103
 arbitrary clipping planes, effect on, 137
 stack, 135
- motion blur, 402
 stippling, with, 507
- motion**, See animation
- movie clips, 527
- multiple layers
 displaying with overlap, 511
- N**
- name stack, 471–475
 creating, 472
 initializing, 472
 loading, 472
 multiple names, 483–485
 popping, 472
 pushing, 472
 querying maximum depth, 473
- networked operation, 34–35
 attribute groups, saving and restoring, 78
 display lists, 264
 versions, 504
- Non-Uniform Rational B-Splines, see NURBS
- nonplanar polygons, 39

normal vectors, 63–65, 178
calculating, 588
calculating for analytic surfaces, 588
calculating for polygonal data, 591
calculating length, 65
cross product, calculating normalized, 85
enabling automatic unit length division, 65
inverse matrix generated, 533
matrix transformations, 96
normalized, 65
NURBS, generating for, 463
quadrics, generated for, 430
rendering pipeline stage, 12, 531
specifying, 64
tessellation, specifying for, 415
transformations, 595
unit length optimizes performance, 603
vertex arrays, specifying values with, 68
normal, See normal vectors
normalized device coordinates, 96
NURB Curves and Surfaces (book title), 439
NURBS, 455–468
 creating a NURBS curve or surface, 462–464
 creating a NURBS object, 459
 culling, 460
 deleting a NURBS object, 460
 display list use, 256
 error handling, 462
 method of display (lines or filled polygons), 460
 normal vectors, generating, 463
 properties, controlling NURBS, 460
 querying property value, 461
 references, 439
 sample program which draws a lit NURBS surface, 456
 sample program with a trimmed surface, 467
 sampling precision, 460
 source for matrices, 461
 steps to use, 455
 texture coordinate generation, 463
 trimming, 464–468
NURBS Book, The, 439
NURBS for Curve and Surface Design, 439

O

object coordinates, 96
 texture coordinate generation, 364
objects, See models
opacity, 215
Open Inventor, 3, 15
OpenGL Extension to the X Window System, see GLX
OpenGL Programming for the X Window System, xxii, 15, 16, 562, 579
OpenGL Reference Manual, xxi, 529, 536, 562
OpenGL Utility Library, see GLU
OpenGL Utility Toolkit, see GLUT
orthographic parallel projection, 101, 124–125
 jittering, 400
 matrix, 598
 specifying with integer coordinates, 601
outlined polygons, 55, 63
 polygon offset solution, 247
overlapping objects, 518

P

painting, 215, 218, 528
partial disks, 428
pass-through markers, 494
performance tips
 clearing the window, 32
 display lists, 256, 257
 flat shading, 603
 flushing the pipeline, 34
 fog, 240
 GLX tips, 603
 hints, 228
 light source attenuation, effect of, 184
 light sources, effect of additional, 178
 list of general tips, 602
 material properties, changing, 602
 NURBS and display lists, 256
 pixel data alignment, 301
 pixel data, drawing, 314
 polygon restrictions, 39
 polygon subdivision, 82

-
- pushing and popping attribute groups, 602
 rasterization and fragment operations for pixel data, 603
 removing hidden surfaces, 173
 specifying geometric primitives, 603
 tessellation and display lists, 256
 tessellation, use of, 426
 texture images, internal format of, 328
 texture objects, 346, 602
 texture subimages, 602
 two-sided lighting, 195
 unit-length normal vectors, 603
 vector and scalar forms of commands, 603
 vertex arrays, 603
 perspective projection, 120–123
 correction hint, 228, 326
 depth coordinates, effect on, 128
 jittering, 397
 matrix, 598
 perspective division, 96
 PGL, 14
 `pglChooseConfig()`, 570, 572
 `pglCopyContext()`, 571, 572
 `pglCreateContext()`, 571, 572
 `pglDestroyContext()`, 571, 572
 `pglGetCurrentContext()`, 571, 573
 `pglGetCurrentWindow()`, 571, 573
 `pglGrabFrontBitmap()`, 571, 573
 `pglIsIndirect()`, 571, 572
 `pglMakeCurrent()`, 571, 572
 `pglQueryCapability()`, 570, 572
 `pglQueryConfigs()`, 570, 572
 `pglQueryVersion()`, 570, 572
 `pglReleaseFrontBitmap()`, 571, 573
 `pglSelectColorIndexPalette()`, 572, 573
 `pglSwapBuffers()`, 571, 573
 `pglUseFont()`, 572, 573
 `pglWaitGL()`, 571, 573
 `pglWaitPM()`, 571, 573
 picking, 478–488
 back buffer for, using the, 508
 depth coordinates, 485
 hierarchical models, 483–485
 projection matrix, special, 479
 sample program, 480
 sample program with depth coordinates, 486
 strategies, 489
 sweep selection, 490
 Piegl, Les, 439
 pipeline
 geometric processing, 530–532
 imaging, 291, 296–308
 rendering, 10–14
 vertex transformation, 96
 pixel
 coverage, 227
 pixel data, 278, 289–295
 also see images
 byte alignment, 301
 byte ordering, 300
 copying within the framebuffer, 13, 290, 295, 296, 532
 depth buffer pixel data, 295, 303
 drawing or reading a subrectangle of, 301
 drawing process in detail, 309–312
 endianness, 300
 feedback mode, 493
 formats for reading or drawing, 292
 formats for storing in memory, 293, 298
 mapping, 12, 304, 532
 packing into processor memory, 13, 298–300, 532
 performance tips, 314
 pipeline operations, 12, 291, 296–308, 532
 pixel zoom, 305
 querying pixel mapping information, 304
 reading from the framebuffer, 290, 292
 reading process in detail, 312–314
 sample code which draws an image, 294
 sample program which draws, copies, and zooms pixel data, 306
 stencil buffer pixel data, 293, 303
 storage modes, 299
 transfer modes, 13, 302, 354, 532
 unpacking from processor memory, 12, 298–300, 532
 writing to the framebuffer, 290, 294
 point light source, See positional light source
 points, 37
 antialiasing, 228–235, 514
 drawing, 42
 feedback mode, 493
 querying point size, 50
 round, 228–235, 514
 size, 49

specifying, 43, 44

polygon offset, 247–250

- depth slope of a polygon, 248
- enabling, 247
- hidden-line removal, 521

polygonal approximations to surfaces, 81

polygons, 38

- boundary edges, 62–63
- concave, drawing filled, 410, 516
- convex, 38
- culling the faces, 56
- drawing, 42
- drawing as points, lines, or filled, 55
- feedback mode, 493
- front and back faces, 56
- holes in, 38
- non-convex, 38, 62
- nonplanar, 39
- polygon mode, 12, 55, 532, 603
- reversing the faces, 56
- sample program with stippled polygons, 60
- self-intersecting, 416
- simple, 38
- specifying, 43, 45
- stippling, 57
- tessellation, specifying for, 423
- Voronoi, 524

positional light source, 182

primitives

- geometric, 37–48
- raster, 278

priority of texture objects, 352

Procedural Elements for Computer Graphics, 428

programs

- aaindex.c, 232
- aapoly.c, 236
- aargb.c, 229
- accanti.c, 401
- acopersp.c, 397
- alpha3D.c, 223
- alpha.c, 220
- bezcurve.c, 441
- bezmesh.c, 451
- bezsurf.c, 448
- checker.c, 323
- clip.c, 138

- colormat.c, 202
- cube.c, 98
- dof.c, 404
- double.c, 24
- drawf.c, 280
- feedback.c, 495
- fog.c, 240
- fogindex.c, 245
- font.c, 287
- ftp site, xxii
- hello.c, 18
- image.c, 306
- light.c, 176
- lines.c, 53
- list.c, 259
- material.c, 199
- mipmap.c, 340
- model.c, 112
- movelight.c, 189
- pickdepth.c, 486
- picksquare.c, 480
- planet.c, 141
- polys.c, 60
- quadric.c, 433
- robot.c, 144
- select.c, 475
- smooth.c, 166
- stencil.c, 387
- stroke.c, 269
- surface.c, 456
- tess.c, 414, 415, 424
- texbind.c, 348
- texgen.c, 365
- texsub.c, 333
- texturesurf.c, 452
- torus.c, using a display list, 253
- trim.c, 467
- unproject.c, 148
- varray.c, 69

projecting images, 523

projection matrix, 101, 103

- matrix stack, 135
- orthographic parallel projection matrix, 598
- perspective projection matrix, 598
- shadows created with, 520

projection transformations, 100, 120–125

- camera lens analogy, 94

collapsing geometry to a single plane, 600
jittering, 397, 400
orthographic parallel, 101, 124–125, 601
perspective, 120–123
picking, 479
texturing effects, 372
two-dimensional, 125
proxy textures, 330

Q

q texture coordinates, 372
 avoiding negative values, 601
quadratic attenuation, 184
quadrics, 428–436
 creating an object, 429
 destroying an object, 429
 drawing as points, lines, and filled polygons, 430
 error handling, 429
 normal vectors, generating, 430
 orientation, 430
 quadratic equation, 428
 sample program, 433
 steps to use, 428
 texture coordinates, generating, 431
quadrilateral
 specifying, 43, 45
 strip, specifying, 43, 45

R

raster position, 282
 after drawing a bitmap, 283
current, 282, 533
current raster color, 285
current, obtaining the, 282
 transformation of, 282
rasterization, 156, 374
 exact, two-dimensional, 601
 rendering pipeline stage, 13
reading pixel data, See pixel data
Real Projective Plane, The, 593
rectangles

specifying, 40
reducing images, 305
reflecting objects, See scaling
reflection, See material properties
reflective objects, See environment mapping
refresh, screen, 21
removing hidden surfaces, See hidden-surface removal
repeatability, 606
resident textures, 332, 351
 management strategies, 352
 querying residence status, 351
RGBA mode, 157
 changing between color-index mode and, 162
 choosing between color-index mode and, 161
 coverage calculations for antialiasing, 227
 data type conversion, 163
 light source colors, 175
 lighting calculations in, 205
 material property values, 176
 vertex arrays, specifying values with, 68
robot arm example, 143–146
Rogers, David, 428
Rossignac, Jarek, 518
rotating images, 523
rotation, 109
 matrix, 596

S

sample programs, See programs
scaling, 110
 matrix, 596
scaling images, 523
Schneider, Bengt-Olaf, 518
Scientific American, 526
scissor test, 383
 and clearing, 379
 rendering pipeline stage, 14, 533
Segal, Mark, 372
selection, 470–491
 back buffer for, using the, 508
 hit records, 474

-
- programming tips, 489
 querying current rendering mode, 472
 rendering pipeline stage, 532
 sample program, 475
 steps to perform, 471
 sweep selection, 490
 shading
 flat, 165
 performance tips, 603
 sample program with smooth shading, 166
 smooth, 165
 specifying shading model, 165
 shadows, 205, 406, 520
 shininess, 198
 also see environment mapping
 silhouette edges, 82
 smoke, See fog
 smooth shading, 165
 solar system example, 140–143
 source factor, See blending
 specular
 contribution to lighting equation, 208
 light, 174
 material properties, 175, 198
 spheres, 428, 583
 split-screen
 multiple viewports, 126
 spotlights, See light sources
 state machine, 9–10
 state variables, 48
 attribute groups, 78–81
 display list execution, effect of, 273
 enable and disable states, 48
 list of, 537–559
 performance of storing and restoring, 602
 querying, 49
 stencil buffer, 376, 377
 clearing, 32, 379
 concave polygons, for drawing, 516
 decals, for, 515
 Dirichlet domains, for, 525
 Game of Life, for the, 526
 hidden-line removal, 522
 masking, 381
 pixel data, 293, 303
 stencil test, 385–391
 examples of using, 387
 interference regions found using clipping planes, 519
 querying stencil parameters, 386
 rendering pipeline stage, 14, 533
 sample program, 387
 stereo, 377, 380
 querying its presence, 377
 stippling
 display lists cache stipple patterns, 258
 enabling line stippling, 51
 enabling polygon stippling, 58
 fade effect, use for, 507
 line pattern reset, 52, 493, 497
 lines, 51
 polygons, 57
 sample program with line stipple, 53
 sample program with polygon stippling, 60
 stencil test, use of, 391
 translucency, use to simulate, 506
 stitching, 247
 stretching objects, See scaling
 stride
 vertex arrays, 70, 76
 subdivision, 81–89
 generalized, 88
 icosahedron example, 86
 recursive, 88
 subimages, 332–335, 336
 superimposing images, 515
 surface normals, See normal vectors
 surfaces, See evaluators or NURBS
 swapping buffers, See double-buffering
 syntax, See command syntax
- T**
- Terminator 2*, 370
 tessellation, 39, 410–428
 backward compatibility with obsolete routines, 426
 begin and end callback routines, 414
 callback routines, 412–417

-
- combine callback routine, 414, 416
 - computational solid geometry, winding rules used for, 421
 - contours, specifying, 423
 - converting code to use the GLU 1.2 tessellator, 427
 - creating an object, 412
 - decomposition into geometric primitives, 414
 - deleting objects, 426
 - display list use, 256
 - edge flag generation, 414
 - error handling, 414
 - evaluators used to perform, 602
 - interior and exterior, determining, 418–422
 - intersecting contours combined, 414, 416
 - performance tips, 426
 - polygons, specifying, 423
 - properties, 417–422
 - reuse of objects, 412, 426
 - reversing winding direction, 422
 - sample code, 414, 415, 424
 - user-specified data, 417
 - vertices, specifying, 415, 423
 - winding rules, 418–422
 - texels, 14, 318
 - text, see characters
 - texture coordinates, 326, 357–371
 - assigning manually, 357
 - avoiding negative q values, 601
 - clamping, 360–363
 - computing manually, 358
 - enabling automatic generation of, 369
 - environment mapping, automatic generation for, 370
 - evaluators, generated by, 452
 - generating automatically, 364–371
 - NURBS, generating for, 463
 - q coordinate, 372
 - quadrics, generated for, 431
 - reference planes, specifying, 364
 - rendering pipeline stage, 12, 531
 - repeating, 360–363
 - sample program with texture coordinate generation, 365
 - tessellation, specifying for, 415
 - vertex arrays, specifying values with, 68
 - wrapping modes, 360–363
 - texture functions, 354–357
 - blend, 356
 - blending color, 356
 - decal, 326, 356
 - fragment operations, 356
 - modulate, 356
 - pixel-transfer modes effect, 354
 - replace, 356
 - texture internal format, interaction with, 354
 - texture images
 - alpha data, 354
 - borders, 337, 361
 - components, 327
 - data types, 328
 - distorting, 359
 - framebuffer as a source of, 329, 334, 336
 - imaging pipeline operations, 297
 - intensity data, 354
 - internal format, 327
 - luminance data, 354
 - mipmaps, 338–344
 - one-dimensional, 335–337
 - performance affected by internal format, 328
 - performance of texture subimages, 602
 - power of 2 size restriction, 329
 - proxy textures, 330
 - querying maximum size, 330
 - residence status, 351
 - resident textures, 332, 351
 - resident textures, management strategies of, 352
 - sample program with mipmaps, 340
 - sample program with subimages, 333
 - specifying, 326–338
 - subimages, 332–335, 336
 - working set of textures, 332, 346, 351
 - texture mapping, see texturing
 - texture matrix, 371
 - rendering pipeline stage, 531
 - texture objects, 326, 346–351
 - binding, 348
 - creating, 348
 - data which can be stored in, 348
 - deleting, 351
 - fragmentation of texture memory, 353
 - least-recently used (LRU) strategy, 353
 - mipmaps, 350
 - naming, 347

-
- performance tips, 346, 602
priority, 352
rendering pipeline, 13, 532
sample program, 323
sample program with multiple texture objects, 348
sharing among rendering contexts, 563, 575
steps to perform, 346
using, 348
- texturing
also see texture coordinates, texture functions, texture images, texture matrix, and texture objects
antialiasing characters, 523
antialiasing lines, 523
blending, 219
border colors, treatment of, 361
color-index mode limitations, 321, 329
creating contours, 365
decals with alpha testing, 385
display lists cache texture data, 258
enabling, 322, 326
environment mapping, 369
filtering, 344–346
image transformations, 523
mipmapping, 338–344, 346
perspective correction hint, 326
rendering pipeline stage, 13, 532
sample program, 323
sample program with evaluated, Bézier surface, 452
sample program with mipmapping, 340
sample program with texture coordinate generation, 365
sample uses for, 523
simulating shadows or spotlights, 372
steps to perform, 321
what's new in release 1.1, 321
- 3D Computer Graphics: A User's Guide for Artists and Designers*, xxi
- 3D models, rendering, 20, 583
Tiller, Wayne, 439
tips, programming, 599
also see performance tips
error handling, 600
selection and picking, 489
transformations, 129
- transformations
also see modeling transformations, projection
- transformations, viewing transformations, and viewport transformations
combining multiple, 139–146
display lists cache transformations, 257
general-purpose commands, 102
matrices, 595–598
mimicking the geometric processing pipeline, 149
modeling, 104, 108–113
ordering correctly, 105–108
overview, 92
performance tips, 602
projection, 100, 120–125
reversing the geometric processing pipeline, 147
sample program, 98
sample program combining modeling transformations, 141, 144
sample program for modeling transformations, 112
sample program showing reversal of transformation pipeline, 148
troubleshooting, 129–131
units, 123
viewing, 104, 113–118
viewport, 102, 125–128
- translation, 108
matrix, 596
- translucent objects, 215, 506
stencil test, creating with the, 390
- transparent objects, 215
creating with the alpha test, 385
- transposing images, 528
- triangle
fan, specifying, 43, 45
specifying, 43, 45
strip, specifying, 43, 45
tessellated polygons decomposed into, 414
- trimming
curves and curved surfaces, 464–468
sample program, 467
- two-sided lighting, 194

U

- up-vector, 99
Utility Library, OpenGL, see GLU

Utility Toolkit, OpenGL, see GLUT

V

van Dam, Andries, *xxi*, 157, 593

van Widenfelt, Rolf, 372

vendor-specific extensions, 505

versions, 503–505

 GLU, 504

vertex, 37

 also see vertex arrays

evaluators, generating with, 440

feedback mode, 493

per-vertex operations pipeline stage, 12, 531

specifying, 41

tessellation, specifying for, 415, 423

transformation pipeline, 96

vertex arrays, 65–77

 dereference a list of array elements, 72

 dereference a sequence of array elements, 74

 dereference a single element, 71

 disabling, 68

 display list use, 264

 enabling, 67

 interleaved arrays, 75

 interleaved arrays, specifying, 76

 performance tips, 603

 querying, 537

 reuse of vertices, 74

 sample program, 69

 specifying data, 68

 steps to use, 66

 stride between data, 70, 76

video

 fake, 527

 flipping an image with `glPixelZoom()`, 306

 textured images, 332

viewing

 camera analogy, 94–95

viewing transformations, 99, 104, 113–118

 connection to modeling transformations, 100

 default position, 99

 different methods, 118

 pilot view, 119

polar view, 119

tripod analogy, 94

up-vector, 99

viewing volume, 121

 clipping, 125, 136

 jittering, 397, 400

viewpoint

 lighting, for, 194

viewport transformations, 97, 102, 125–128

 photograph analogy, 94

 rendering pipeline stage, 12, 532

visual simulation

 fog, use of, 239

Voronoi polygons, 524

W

w coordinates, 37, 96, 102

 avoiding negative values, 601

 lighting, use with, 183

 perspective division, 128, 532

warping images, 523

Watt, Alan, 318

web sites

 IBM OS/2 software and documentation, 570

 Microsoft Developer Network, 574

 Silicon Graphics' OpenGL, *xxii*

 Template Graphics Software, 566

WGL, 14, 574

`wglCopyContext()`, 575, 576

`wglCreateContext()`, 574, 575, 576

`wglCreateLayerContext()`, 575, 576

`wglDeleteContext()`, 576

`wglDescribeLayerPlane()`, 574, 576

`wglDestroyContext()`, 575

`wglGetCurrentContext()`, 575, 577

`wglGetCurrentDC()`, 575, 577

`wglGetLayerPaletteEntries()`, 576, 577

`wglMakeCurrent()`, 575, 577

`wglRealizeLayerPalette()`, 575, 577

`wglShareLists()`, 575, 576

`wglSwapLayerBuffers()`, 575, 577

`wglUseFontBitmaps()`, 576, 577

`wglUseFontOutlines()`, 576, 577

Williams, Lance, 338

Win32

ChoosePixelFormat(), 574, 576

CreateDIBitmap(), 575, 577

CreateDIBSection(), 575, 577

DeleteObject(), 575, 577

DescribePixelFormat(), 574, 576

GetVersion(), 574, 576

GetVersionEx(), 574, 576

SetPixelFormat(), 574, 576

SwapBuffers(), 575, 577

winding rules, 418–422

computational solid geometry, used for, 421

reversing winding direction, 422

window coordinates, 97, 126

feedback mode, 493

polygon offset, 248

window management

glViewport() called, when window resized, 126

using GLUT, 16, 35

working set of textures, 332, 346, 351

fragmentation of texture memory, 353

writemask, See masking (buffers)

writing pixel data, See pixel data (drawing)

X

X Window System, 14, 562

client-server rendering, 5

minimum framebuffer configuration, 376

X Visual, 162, 562

Z

z buffer, See depth buffer

z coordinates, See depth coordinates

zooming images, 305

filtered, 528