## EXPANDED INDEX (includes over 300 entries, mostly code-related, not found in the printed index at the back of the book).

8-bit color components 149-50, 267 24-bit depth buffer 678, 685 32-bit color values 150, 266 32-bit floating-point components 93, 313 128-bit color values 266  A	animation 94, 116, 120-1, 127, 136, 175, 207, 344, 473, 477, 492, 496, 760-3, 776-8, 787-90 entire frame of 94, 136 frames of 116, 118 given frame of 94, 136 next frame of 94, 136
AABB (axis-aligned bounding box) 515-20, 526-7, 530, 532, 546, 609, 616-17, 619-20  AABB/plane tests 525 acceleration 447, 633-5 adapters, default 106, 137-8 address modes 311, 332-5, 338, 342, 636 affine transformations 59, 67-8, 70-1, 80, 86, 737 aliasing 99-100, 674-5, 698 alpha channel 93, 352, 358-62, 381, 406, 422, 587, 591-2, 622, 639, 723 alpha component 148, 183, 287, 339, 348-9, 361, 369, 574 alpha-to-coverage 351, 400, 422-4 alpha-to-coverage blend state object 422 alpha value 362, 370, 422, 424 ambient-access 703, 711, 720 ambient light 281, 284-5, 687, 701, 719, 721	API overhead 202, 510, 526, 530 application code 129-30, 206, 218, 224, 263, 301, 318, 526 application-defined masking value 373 application instance 125-6 application message loop 119, 124, 126 application window, main 124, 126-7 array 58, 103, 105, 115-16, 199, 261, 263, 265, 268, 275, 295, 351-2, 416, 424, 566 aspect ratio 126, 168-71, 174, 184-5, 187, 235, 522, 536-7 assembly code 222 attribute values 181 average, weighted 19, 274-5, 364, 370, 450-1, 460, 779, 781 average frames 126, 128, 137 averaged pixel color 100 AxisAlignedBox 517, 519-20, 526 axis-aligned bounding box see AABB axis directions 548, 550
ambient map 711, 716, 718-19, 723 ambient material color 281, 701 ambient occlusion 496, 701-3, 705-7, 709, 711, 713, 715, 717, 719, 721-3 ambient occlusion demo 703, 705-6 ambient occlusion map 706, 715, 719 ambient term 281, 289, 296-8, 496, 701-2, 719-22 angle acute 11 obtuse 11 angle restriction 747 animating 760, 776, 779, 789	backface culling 179-80, 363, 475 background color 361 basic input/output system (BIOS) 117 basic tessellation demo 493 BasicModel class 732-4, 789 basis, per-triangle 526 basis vectors 503, 507 standard 62, 65, 72 transformed 71-2 Bernstein basis functions 486, 493 Bézier curves 473, 484-7, 493 Bézier Patch demo 494 Bézier quad patches 473

Bézier surfaces 473, 487-8, 493-4	bone space 776
cubic 488	bounding box 495, 517-19, 530, 540-1
quadratic 493-4	bounding sphere 515, 520, 530, 546, 682-3
Bézier triangle patches 480, 494	bounding volumes 509, 515, 520, 526,
Bézier triangle surface patch 493	530, 541, 546, 615-16, 732, 735
biasing 674, 676-7, 693	branching, dynamic 289, 296-8
binding 115, 199, 318, 377, 435, 454,	buffer 94-8, 100-4, 108-16, 127, 130, 136,
467-8, 643-4, 686	195-201, 260-4, 347-8, 379-81, 440-3,
BIOS (basic input/output system) 117	447-8, 454-5, 513-15, 643-4
bird's eye 406, 454-5, 629	32-bit floating-point depth 98, 372
blend 347-8, 354, 356-7, 368-70, 380, 413,	allocated 261
585, 621-2, 691, 735	depth stencil 566
blend demo 362-4, 368-70, 393, 396-7,	entire 197, 562
408, 426	floating-point 468
blend factor color 350	floating-point depth 678
blend factors 349-52, 369	normal/depth 707
destination 348, 350, 354-6, 397	off-screen 371, 392
blend map supplies 621	raw 442
blend maps 620, 622, 627-8	second texture 457
grayscale 621	static 260, 262
blend operations 349, 351, 355, 370, 397	buffer alpha values 349
blend operator 350, 354-6	buffer definitions 230-1
blend parameters 638-9	buffer dimensions 130, 168
blend state 264, 350-1, 353	buffer form 94, 136
default 353	buffer of elements 440, 467
blender 145, 735, 792	buffer pixel color 357
blending 90, 148, 182-3, 210, 347-9,	buffer pixel format 108
351-5, 357-9, 361-3, 369, 422, 620,	buffer pixels 348, 380
638-40, 682, 779-82, 791-2	mirror stencil 390
blending equation 348-50, 354-6, 358,	buffer resources 468
369, 381, 397, 621, 638	buffer textures 94
blending method 357	buffer width 107, 126
blending operators 351-2	buffering, double 94, 108, 136
blending transparency 569 BlendState 353, 651	C
BlendState 353, 651 blocks 97, 371-4, 379, 392, 570, 601, 607,	C
702	camera 18, 163, 165-7, 211, 364-5,
blur 430, 449-51, 453-7, 459-65, 469, 715,	camera 18, 163, 165-7, 211, 364-5, 406-10, 498-503, 505, 507, 549-50,
718-19	554-6, 563, 606-7, 626-8, 654-5
preserving 715-16, 718, 722	first person 495, 497, 499, 501-3, 505,
vertical 453, 456	507
blur radius 451, 461-4	void 501, 503-4
blurred result 455-6	camera basis vectors 500
blurring 450, 457-60, 723	camera class 499, 505, 507
blurring algorithm 450, 455-6	camera coordinate system 164-5, 498, 500,
bone influences 770, 780-2, 792	506-7

comora domo 505.7	color mone 621.2
camera demo 505-7	color maps 621-2
camera frustum 527-8	color operations 147-8, 150, 183
camera position 165, 303, 364-5, 370, 502,	color pixels 314
507	color texturing 678
camera space 163-4, 500	color value 207, 209, 263
camera system 495, 497	color vectors 146-8, 183, 313, 349, 352
camera vectors 504	single 396
cast 24, 110, 116, 126, 134, 174, 220,	colored cube 265-6
235-7, 257-8, 261-2, 313, 332, 506,	COM (Component Object Model) 92-3,
564-5, 664	135
cast rays 703-5, 722	COM interfaces 92-3, 126, 135
change constant buffer variables 226	COM objects 92
change surface format 340, 359	comparison function 374, 681
character 769, 777-8, 781, 791	compiler 197, 214, 216-17, 222
character animation 495-6, 760, 769, 771,	complex numbers 737-41, 766
773, 775, 777, 779, 781, 783, 785, 787,	complicated pixel shader work 684
789, 791	component object model see COM
character mesh 774	components
clamp 148, 183, 237, 332-4, 350, 376-7,	bit floating point 50
439, 463-5, 592, 610, 626, 717	floating-point 94, 313, 636
clip 177, 361-2, 367, 412, 529, 584, 685,	normal 275, 526
=	
690, 707, 776-8, 787, 789	unsigned integer 93, 313
clip function 207, 361, 422	composition 70, 78, 81, 753
clipping 176-8, 204, 388, 672, 678	compressed formats 340-1, 359, 435, 552
color	compressed texture formats 339-40, 576
32-bit 148-50, 183	1 1 00
128-bit 148-9	compute shader 90
blue 146-7	ComputeBoundingAxisAlignedBoxFromPoi
border 332	nts 519-20
destination 355-6, 638	ComputeBoundingSphereFromPoints 520
fog 364, 366, 368, 370, 413, 585, 691	ComputeFrustumFromProjection 523
fogged 365-6	
green 100, 147	constant acceleration 447, 634-5, 661
instance 511	constant buffer values 383
lit 295-7, 366, 368, 413, 585, 691	constant buffer variable 219, 332, 336, 438
new 146-7, 348	constant buffers 205-7, 213, 218-20,
per-vertex 307, 311	263-4, 286, 293, 318, 433-4, 511, 566,
pixel's 557	588
color channels 339, 352, 355, 585	omit 223, 225
color ck 395	constant color 182, 701
color component 146, 148, 150, 573, 575	constant hull shader 473-4, 479, 492, 589,
additional 148, 183	617-18
color elements 191-2, 265	constant interpolation 320-1, 323
color image 574, 594	constant vectors 23, 32
color information 94-5, 101, 313, 422	constant XMVECTOR instances 23
color intensity 397, 638	control point output 476, 493, 591
<b>y</b>	r r r r r r r r r r r r r r r r r r r

control points 156, 472-4, 476-7, 479-81,	D3D11_BIND_UNORDERED_ACCESS
484-5, 487-8, 491-4, 588, 591, 610	435-6, 440, 457
additional 476-7	D3D11_BLEND 349-56, 369, 397, 422,
vertex shader inputs 492	424, 639
convert spherical to Cartesian coordinates	D3D11_BLEND_DESC 351, 353, 422,
235, 302	424
converter 725-6	D3D11_BLEND_OP 349, 351-6, 369,
coordinate matrices 77-9	397, 639
coordinate matrix, change of 77-81, 85,	D3D11_BUFFER_DESC 195, 198, 200-1,
160-1, 163-4, 498, 507, 580	237-8, 245, 257, 260, 263, 440, 443,
coordinate representation 6-7, 74	481, 491, 515, 609-10, 643
coordinates	D3D11_COLOR_WRITE_ENABLE_ALL
barycentric 85, 480	352-3, 423
floating-point 94, 313	D3D11_COMPARISON_FUNC 374-6,
ith 387	392
normal 526	D3D11_CPU_ACCESS 113, 196, 260,
normalized device 170, 174, 177-8,	264, 418, 442-3, 515
535, 667	D3D11_CPU_ACCESS_READ 113, 196,
object's 160	442-3
u-texture 579	D3D11_CULL_MODE 211
vector's 6	D3D11_DEPTH_STENCIL_DESC
corner to-far-plane vector 707, 711	374-5, 377, 380, 382, 385, 391, 393, 720
crate demo 312, 326, 342-4	D3D11_DEPTH_STENCILOP_DESC
crate pixels 347	375-6
creating vertex buffers 409, 646	D3D11_FILL_MODE 211
crevices 572, 585-6, 593, 705	D3D11_INPUT_ELEMENT_DESC
cube map 455, 547-54, 559-69, 699	190-3, 204, 208, 239, 265-7, 301, 316,
dynamic 559-60, 564-5, 568, 699	408, 511-12
cube map demo 551, 569-70	D3D11_INPUT_PER_INSTANCE_DATA
cube map faces 562-3, 568	512
cube map texture 551, 560, 562	D3D11_MAP 260-1, 419, 444, 528
cube mapping 496, 547-9, 551, 553, 555,	D3D11_MAPPED_SUBRESOURCE
557, 559, 561, 563, 565, 567, 569, 582	260-1, 419, 444, 528
cube texture 548, 553	D3D11_MAX_MULTISAMPLE_SAMPLE
CUDA 466-7	_COUNT 102
CUDA cores 429, 432	D3D11_RASTERIZER_DESC 210-11,
current time value 117, 136	363, 385, 677
CXMVECTOR 22	D3D11_RENDER_TARGET_BLEND_DE
CAN VECTOR 22	SC 351-2, 355, 380
D	D3D11_RESOURCE_MISC_GENERATE_
	MIPS 561
D3D_DRIVER_TYPE_HARDWARE	D3D11_RESOURCE_MISC_TEXTUREC
104	UBE 560-1, 568
D3D_FEATURE_LEVEL 102	D3D11_SAMPLER_DESC 325
D3D11_BIND 113	D3D11_STENCIL_OP 376-8, 380, 382,
-	391-2, 394-5
	·

D3D11\_SUBRESOURCE\_DATA 195, depth/stencil buffer 98-9, 103, 111-14, 197-8, 201, 237-8, 245, 257, 263, 440, 125, 127, 132, 150, 314, 354, 372-3, 481, 491, 605, 609-10, 637 556, 640-1, 664, 666 D3D11\_TEXTURECUBE\_FACE main 721 548 D3D11 UNORDERED ACCESS VIEW depth/stencil buffering 436, 441, 448 depth/stencil state 264, 378, 382, 393 DESC D3D11 USAGE default 377 108 D3D11\_USAGE\_STAGING 112-13, 196, depth/stencil state block 374, 376-7, 393 418, 442-3, 520 depth/stencil state object 378, 391 depth/stencil texture D3D11\_VIEWPORT 115-16, 125, 139, depth test 97-8, 207, 357-8, 372, 374-7, 179, 535, 563, 664 380-1, 383, 394, 396-7, 545, 556, 661, D3DX library 19, 137, 213 D3DX11CompileFromFile 216-18, 220, 673, 695 223, 238-9 depth values 97-8, 172-3, 181, 207, 375, 533, 666, 673-4, 676, 678, 691, 695, D3DX11CreateEffectFromMemory 217-18, 223, 239 697, 707, 715 D3DX11CreateShaderResourceViewFromFi corresponding 97-8 normalized 172, 556, 688 135, 317-18, 323, 327, 340-2, 553, pixel shader modifies 568 derivatives, partial 304, 488, 490, 494, 693 D3DX11CreateTextureFromFile 317, 323, destination blend factor Fdst 418 352 destination pixel colors data elements 429, 448, 468 array of 93, 135, 312 diffuse light 281, 283-4, 308, 558 diffuse light color 280 matrix of 93, 312 116, 126, 130, 204, 293, diffuse lighting 280, 285 data members diffuse lighting calculation 415, 499 280 diffuse material data structures 280, 285, 287, 300, 330, 447, 725, 734 323, 340-2, 553, 568 359, 368-9, 413, 585, 691 DDS file DDS texture image format 551 diffuse material color 280 debug output window 193-4, 222 Direct3D buffers 195, 263 depth bias 676-8, 693 Direct3D functions 92, 134-6 depth buffer 95-8, 100-2, 111-12, 114, Direct3D resources 90, 201, 430-1 134-5, 144, 357-8, 371-5, 383, 392, 566, direction tangent 628 673-4, 677-8, 684-5, 720-1 direction vector 287, 559 depth buffer range 116, 535 directional lights 90, 270, 287, 291, 299, depth buffering 89, 91, 95-6, 98, 136, 179, 302, 306, 308, 390, 393, 699 375 directional shadow matrix 387 depth buffering algorithm 104, 213, 221, 341, 552, 172, 181 DirectX SDK depth comparison test 720 576, 790 depth complexity DirectX Texture Tool 372, 394-6 323, 340, 342, 547, depth coordinates 172, 536 552-3, 568 depth in NDC space 671, 687 disable pixel shader 642, 653, 659 DepthStencilState Dispatch\_Thread\_ID 378, 556, 641, 651, 657 437, 445-7 depth settings 375, 393 displacement mapping 158, 469, 484, 496, 571, 573, 575, 577, 579, 581, 585, 587, depth stencil 562, 566 depth/stencil 589-95, 610-11, 613 103, 115, 125, 127, 130

displacements 2, 4, 72, 338, 586-7, 593, 686, 721 distance fog start 364, 370 function of 289, 365, 368 distance calculation 588, 610 domain 332, 338, 476-7, 480, 483-4, 591-2, 613, 668 normalized texture space 337 domain shader 151, 431, 472, 474, 479-80, 483-4, 492-4, 585, 587, 591-3, 607, 613, 615, 627 dot product 10-12, 15, 27, 32, 40-1, 55, 68, 87, 147, 183, 228, 276, 507, 753	effects framework 90, 189, 206, 212-13, 216-17, 223, 225-6, 264, 306, 368, 434, 441 elements, vertex shader output 204 emit position/direction 650, 656 emitter particles 647, 654, 660   single 647-8 environment map 496, 549-51, 554, 557-9, 568, 596, 687 environment mapping 495-6, 549-50, 558-9, 595, 727 equation, parametric 121, 493, 635 eye position 280, 282, 307, 533, 611, 632
dot product properties 34	F
driver 99, 104-6, 125, 314, 478	
DXGI_FORMAT_R32G32_UINT 93, 313  DXGI_FORMAT_D16_UNORM 98  DXGI_FORMAT_D24_UNORM_S8_UIN     T 98, 113, 372, 392, 665  DXGI_FORMAT_D32_FLOAT 98  DXGI_FORMAT_D32_FLOAT_S8X24_UI     NT 98  DXGI_FORMAT_R16G16B16A16_     UNORM 93, 313  DXGI_FORMAT_R32_UINT 201, 236, 257  DXGI_FORMAT_R8G8B8A8_SINT 93, 191, 313  DXGI_FORMAT_R8G8B8A8_SNORM 93, 313  DXGI_FORMAT_R8G8B8A8_SNORM 93, 313  DXGI_SAMPLE_DESC structure 102  DXGI_SWAP_CHAIN_DESC 103, 107  DXGI_SWAP_CHAIN_FLAG_ALLOW_MODE_SWITCH 107  DXTrace_function 134, 136	far plane 168, 173-4, 176-7, 184, 186-7, 364, 499, 502, 507, 521-3, 527, 555, 666-7, 697, 708  far plane values 184-5  fetch, vertex texture 262  fetching texture samples 454  field, horizontal 168-9, 502, 551  files, fx 215-16, 318, 327  filtering 362, 680-1  anisotropic 323-5  linear 321-4, 480  filters 93, 135, 312, 319, 323-5, 328, 334, 410, 418, 439, 549, 681, 688-9, 712, 717  final transformation matrices 780, 792  flashlight 290, 303, 308  flatten 222, 296-8, 390, 452  float  16-bit 605  32-bit 20, 605  last 291-2
dynamic buffers 260, 262, 264, 514	
dynamic butters 200, 202, 204, 314	1
<b>E</b> edge vectors 577-8	patch center 612 random 636 return 229, 484, 489, 707 static 128, 295
corresponding texture triangle 577	texture 712
edges	float access 711, 715
triangle's 34, 274	float occlusion 713, 715
upper-triangle 625	float offset 638, 652, 657
	floating-point height values 603

floating-point imprecision 30-1	frustum properties 500-1
floating-point number 373	function
floating-point numbers 30-1, 575, 680	cosine 282-3
floating-point values 31, 99, 148, 314	interpolating 321
forces 2, 4, 8-9, 119	vector-valued 332, 579
	· · · · · · · · · · · · · · · · · · ·
format 93-4, 98-9, 102, 111-12, 114, 191,	velocity 634
201, 312-14, 339-40, 359-60, 435-6,	functionality, vertex texture fetch 262
601, 641, 725-7, 730	
custom 725-6	$\mathbf{G}$
depth-buffer 678, 685	
floating-point 442, 574	GameTimer 118, 121, 123, 266
possible 442	Gaussian blur 451, 453, 722
format DXGI, 32-bit pixel 723	Gaussian function 451, 453
format property 442	geometric interpretation 8, 12, 45, 71, 345,
FPS (frames per second) 119, 126, 128-9,	739
137, 269, 344, 529	geometric primitives 152-3
frame	geometric transformations 37, 59, 72
camera space 499	geometry
complete 94, 136	arbitrary 496, 669, 697
origin of 76	blended 358
previous 119-20	non-blended 357-8
y-axes of 75-6	object's 159
z-axes of 75-6, 83	· ·
	$\mathcal{E}$
frame F0 772	geometry resolution, projected screen 323
frame matrix, change of 77-8, 83	geometry shader 156, 176, 206-7, 262,
frame of reference 5-6, 74, 80, 83, 121	399-403, 405, 407-11, 413-15, 423-7,
frame rate 116, 129, 137, 368	471-2, 565-8, 631-3, 640-2, 644-5, 647
frame texture 344	optional 213, 264
first 344	geometry shader body 400, 402
next 344	geometry shader implementation 401, 567
frames per second see FPS	geometry shader inputs 176, 399
framework 105, 124, 127, 212, 369, 372	geometry shader outputs 399, 641
vector algebra 19	geometry shader programs 319, 399
framework functions 124, 132	geometry shader signatures 402, 415, 424
virtual 124	geometry shader stage 150, 176, 399, 423
framework methods 124, 126	geosphere 252
front buffer 94-5, 136	GPGPU programming 429-431, 445
frustum 166-8, 170, 176-7, 184, 186-7,	GPU (graphics processing unit) 90,
	112-13, 175, 195-7, 262-3, 340-1,
499, 501-2, 509, 515, 521-7, 530-1,	
533-4, 618-19, 627, 670-3	429-30, 445, 466, 530, 611, 640, 642-3,
projector's 672, 698	645, 661
frustum culling 475, 493, 495, 509, 511,	GPU memory 104, 112, 158, 196, 219-20,
513-15, 517, 519, 521, 523-7, 529-31,	262, 339-40, 342, 442, 640
546, 567, 569, 615	GPU resources 112, 150-1, 196, 430-1,
frustum plane equations 178, 522	442, 472, 640
frustum planes 177, 521, 524-5, 615, 619	grass texture 336, 338, 620

ID3D11DeviceContext::Dispatch

ID3D11DeviceContext::Draw

467

432,

200, 263

481, 492-3, 587-9, 591, 610

hull shader constant function

591

control point 473, 476-7, 479, 492-3,

ID3D11DeviceContext::DrawIndexed 201, 255, 263, 266 ID3D11DeviceContext::DrawIndexedInstan ced 513, 530 ID3D11DeviceContext::DrawInstanced 514 ID3D11DeviceContext::GenerateMips	ID3DX11EffectScalarVariable 218 ID3DX11EffectShaderResourceVariable 318, 327, 435-6, 440-1, 554 ID3DX11EffectTechnique 194, 219-20, 234 ID3DX11EffectTechnique::GetPassByIndex 220
561 ID3D11DeviceContext::IASetIndexBuffer	ID3DX11EffectUnorderedAccessViewVaria ble 436-7, 440-1
201, 263 ID3D11DeviceContext::IASetVertexBuffers 199, 263	ID3DX11EffectVariable 219, 293 ID3DX11EffectVectorVariable 218-19 identity matrix 37, 43-4, 48, 52, 55, 68, 78,
ID3D11DeviceContext::Map 196, 260, 264, 408 ID3D11DeviceContext::OMSetBlendState	163, 276 IDXGIFactory 103 IDXGISwapChain::GetBuffer 110-11
350, 352 ID3D11DeviceContext::OMSetDepthStencil	IDXGISwapChain::Present 94, 127, 454 IDXGISwapChain::Present method 127,
State 377 ID3D11DeviceContext::RSSetState 211,	454 IDXGISwapChain::ResizeBuffers 94
266 ID3D11DeviceContext::RSSetViewports 116	IDXGISwapChain instance 103 IDXGISwapChain interface 94, 131, 136 illusion 141-2, 338, 372, 406, 554-5, 586,
ID3D11DeviceContext::Unmap 262, 264 ID3D11DeviceContext interfaces 103, 135	594, 596, 639-40, 656 image
ID3D11InputLayout 190, 193-5, 234, 263 ID3D11RasterizerState 210-12, 264, 363, 385	blurred 450-1, 456 grayscale 339, 359, 585, 691 image borders 463-5
ID3D11RasterizerState objects 211-12 ID3D11Resource 260, 312, 340, 418, 420 ID3D11SamplerState 325	image color 101 image data 90, 93-5, 135, 312, 339, 417 image editors 598, 600-1
ID3D11SampletState 323 ID3D11ShaderResourceView 99, 314, 317-18, 327, 417, 419-20, 436-7, 441, 459, 553, 637-8, 646, 664-5, 733, 789	image file 317, 323, 340, 342-3, 360, 580 immutable 112, 196, 198, 200, 237-8, 245, 257, 481, 491, 609-10, 637
ID3D11Texture1D 312, 637 ID3D11Texture2D 93, 110-11, 114, 125, 312, 317, 340, 415, 418, 424, 436, 454,	immutable resource 112, 196 implementation 118, 120, 126-7, 130, 203, 248, 291, 306, 400-1, 450, 456-7, 502,
553, 561-2, 568 ID3D11Texture2D interface 312, 415, 424, 568	593, 604, 646 incident 557, 570, 585, 691 increment 344, 376-7, 390, 394, 527, 789
ID3D11Texture2D object 317, 415, 553 ID3D11Texture2D object stores 553 ID3D11UnorderedAccessView 436-7, 441, 459	index, linear 420-1 index buffer stores indices 200 index buffers 200-2, 210, 237, 242, 245-6, 255-7, 259, 262-3, 427, 434, 513-14,
ID3DX11EffectMatrixVariable 218, 234 ID3DX11EffectPass 220 ID3DX11EffectPass::Apply 220	608, 731, 735 large 202, 266 index of refraction 569-70

index offset 255 indexing 447, 461 indexing and sampling textures 437 indices, matrix palette 792 indices of refraction 570 indirect light 272, 281, 289, 308, 687, 701, 721 information, real-time using screen space 706	interpolate texture coordinates 404 interpolated to-far-plane vector input 707 interpolation bilinear 320, 480, 484, 613, 678 repeated 485-6 spherical 756, 765 IntersectAxisAlignedBoxFrustum 526, 529 intersection, nearest triangle 540, 546
initialization code 126-7	intersection points 177, 386, 388, 541-2,
input assembler 151-2, 415, 423, 431, 510, 530, 640 input assembler stage 150, 152, 201, 210, 414, 424, 511, 530 input buffer 444, 448, 469, 644 input element 512 input image 453, 456, 461 input layout 190, 193-5, 210, 239, 263, 307, 511-12 using 195 input layout description 190, 193, 263, 301, 307 input parameters 193, 204, 401 input primitives 176, 399, 401-2, 405	intersection tests 527, 530-1, 539, 546 frustum/AABB 525 frustum/sphere 524 ray/sphere 541 ray/triangle 540-2, 546, 705 IntersectRayAxisAlignedBox 540-1 IntersectRaySphere 541 IntersectRayTriangle 540, 542 IntersectSphereFrustum 524 inverses and change of coordinate matrices 78 inward facing planes 524-5 iterate 243-4, 248, 533, 540-1, 609
input registers 194 input signature 193-4, 204-5, 230-2	K
input slots 191-2, 198-200, 265, 513, 644	
single 191-2, 265	key frames 760-3, 776
input texture 447, 456, 459	first 761
input texture coordinates 332	last 761
input texture resources 435	list of 760-1, 776, 785
input triangle 566	key texturing topics 90
input vertex buffer bound 644	
instanced buffer 513-14, 527-30	T
dynamic 527	L
instancing 161, 254, 495, 509-13, 515, 517, 519, 521, 523, 525, 527, 529-531	Lambert's Cosine Law 278-80, 282, 285,
instancing, advanced technique of 192	287 287
integer indices 438	large PCF kernels 692-3
using 438	layers 364, 620-2, 627
integer tessellation factor values 477	light
integers, unsigned 94, 98, 201, 313, 372	active 227
intensity of red light 146	array of 291-2
interchanging 43, 55	blue 146-7, 270-1, 280, 302, 308
intermediate points 485-6	first 687, 690
interpolate rotations 496	incoming 271, 278, 284, 496, 702, 722

key 306	load meshes 725-6
spot 287, 299, 302, 306	load time 340, 342
using colored 302, 308	loads 3-element UINT array 21
light colors 270, 302	location, base vertex 203
light intensity 270, 282, 289-92, 672	loop 219, 250, 604, 682, 777, 779, 785-6
light mixture 146	ray/triangle intersection 544
light projector 670, 672	low intensity colors 397
light rays 4, 148, 271-2, 278-9, 281, 287-8,	lower triangle DCB 626
296, 386, 388	_
light receptors 271	M
light scatters 280-1	
light source 90, 144, 183, 270-2, 281, 287,	magnification 319, 321-2, 324, 342, 422,
289, 292, 306, 389-90, 664, 673-4,	622
676-7, 687-8, 696-7	magnitude 4, 6, 9-10, 18, 31, 67, 83, 548,
light source emits 283-4	739-41, 745, 758, 765, 792
light space 683, 694-7	map, normal/depth 707-8, 710, 715
light space depth 695, 697	map vertex shader outputs 204, 208
light strikes 271, 273, 279-81, 283, 287,	maps frame 83, 85
308	match vertex elements 204, 208
light vector 278-80, 284, 288, 290, 297-8,	material mat 296-8, 728
594, 672	material values 285-6, 307
light vector aims 287, 296	mathematical objects 496, 737
LightHelper.fx 296-9, 328, 410, 581-2,	matrices row vectors 38
686, 688	matrix
lighting	initialize 50
direct 284	orthogonal 65, 83, 87
dynamic 573	row 460
specular 281, 285	square 43-5, 48, 55
lighting calculations 227, 273, 289, 301,	to-parent 772-3, 791
305, 307, 572, 581, 593-4	matrix addition 39, 743
lighting demo 299, 301, 308-9	matrix algebra 2, 37, 39, 41, 43, 45, 47-9,
lighting equation 147, 270, 281, 289, 301,	51, 53, 55, 57
307, 496, 557-8, 686, 701, 719	matrix-column vector ordering 751 matrix elements 38, 752
lighting models 269, 272, 281, 721 real-time 701	matrix equation 48, 55, 59, 389, 577, 694,
line segment 87, 274, 426, 485-6	751, 754
line strip 154, 156, 265, 402, 424	matrix equation Ax 543, 754
linear combination 37, 42, 56, 61, 71-2, 85	matrix inverses 48
linear interpolation 182, 320-1, 323, 332,	matrix-matrix multiplication 59, 72-3, 78,
623, 627, 756, 758-60	83
linear transformation 45, 60-2, 65, 67-8,	matrix minors 45
70, 72, 83-4, 86, 187	matrix multiplication 40-2, 44, 48, 55, 58,
list	68, 72-3, 78, 83, 85, 171, 205, 276, 387,
current particle 642, 649	393
updated particle 642	matrix of pixels 99-100, 450-1
lit skull demo 305-7, 345	matrix product 55-6, 78, 742
,	•

matrix representation 60-2, 65, 67-9, 77,	mountains, distant 547, 550, 554
171, 187, 765	multi-pass texturing technique 213
standard 83-4, 86	multiplication 44, 58, 296, 332, 387, 389,
matrix types 50	738-9, 742, 745, 747, 764
maxtessfactor 477-8, 483	multiprocessor 432, 448-9, 467-8
memory	multisampling 89, 91, 93, 101-2, 312, 351,
run-time 133, 234	353
video 112, 196-7, 430	using 353, 370
mesh	,
continuous 779-81, 791-2	N
land 304, 336, 338	
skull 259, 517, 527, 529, 725, 760	name 27, 134, 216, 230-2, 361, 365, 371,
mesh data 731-3, 735, 789	435, 777, 785, 789
mesh geometry 540, 572, 731	NDC coordinates 171, 669-70, 672, 674
mesh hierarchies 771, 791	NDC space 171, 178, 186, 522, 530-1,
mesh index buffer 545	536-7, 667, 669-72, 687-8, 708, 712,
mesh surface 273, 287, 308	717
mesh triangles 540, 546, 705	nearest ray/triangle intersection 540
mesh vertices 255	non-XMVECTOR parameters 23
mesh viewer demo 734	normal/depth 720-1
messages 126-7, 129-31	normal mapping 93, 312, 495, 571, 573,
meters 4-5, 628, 635	575, 577-85, 587, 589, 591, 593, 595,
minification 322-4, 342	614, 690, 727
minimum depth buffer value 116	normal maps 339, 571, 573-7, 580-2,
minimum point 63, 66, 69	585-7, 591, 593-6, 615, 622, 723
mipmap chain 318, 322-3, 342-3, 420, 681	normal vector direction 585, 593
mipmap levels 93, 111-12, 114, 312, 323,	normal vector visualization technique 426
342-3, 419-21, 437-8, 592-3, 638	normal vectors 152, 179, 181, 249, 259,
mipmaps 111-12, 114, 322-3, 420, 638,	273-4, 276-9, 304-5, 531-2, 570-1, 573,
678	577-8, 580-2, 585-6, 615
mirror 287, 292, 332-4, 371-2, 378-84,	sampled 581
397, 557	transformed 276
mirror demo 386, 390, 393, 397	normalized range 146, 149, 172, 183, 587
mirror pixels 382-3	normalized texture-coordinates 438
visible 383-4	normals, per-pixel 593
mirror plane 379	null depth/stencil buffer 642
mode	null pixel shader 685-6
debug 105, 134, 137, 213, 216, 221	449-50, 463-4, 467
full-screen 108, 110, 131-2	number, random 636, 651, 656
wireframe 189, 212, 262, 266, 545, 593,	numthreads 433-4, 437-9, 443, 447,
629	NVIDIA hardware 432, 467
model formats	NVIDIA texture tools 341-2
custom 725	
standard 725	0
model reflections 547, 557	
1-1 145	

modelers 145

OBB (oriented bounding box) 518-19,	operator 24, 26, 28, 35, 51-3, 296, 349,
530-2, 620	369, 374, 392, 439, 467, 749
object space 576-80	overloaded 24, 27, 51
object space coordinates 578-80	oriented bounding box see OBB
objects	origin 5, 76-7, 88, 159, 161-4, 168-9,
animated 559-60, 568	498-9, 507, 521-3, 537-8, 546, 548-9,
blend state 352-4	554, 623-4, 634-5
blended 357-8	orthogonalization 13
cbuffer 206	orthogonalize 13-14, 17-18
child 770, 791	orthographic projections 663, 666-7,
destination resource 420	672-3, 697-9
distant 364	orthonormal set 13-15
effect 219, 409	output, initialize 296-8
geometric 515, 530	output buffer 443, 447-8, 468-9, 644
global illumination models light 272	output control point 477
group of 96, 143	output image 456
key 560, 568	output merger 151, 182-3, 431
multiple 206, 246, 254	output merger (OM) 103, 110, 114, 150-1,
output XMVECTOR 26, 28, 35	182-3, 352, 377, 393, 396, 431
placing 623, 627	output merger stage 103, 110, 114, 150,
sampler 324, 334, 681	182, 352, 377, 393, 396
semi-transparent 347, 369, 640	output parameters 204-5, 209, 401
single 776	output primitives 399, 402, 423
solid 180, 710	output resources 434-5
state 212, 218, 307	output signature 228, 230-2
state group 212	output texture 466
transparent 270, 357	output triangle lists 402
tree 160, 510	output vertex attributes 329, 367, 470, 511,
occludes 180, 381, 383, 698, 702-3,	583, 589, 611, 689, 706, 782
710-11, 713, 715	output vertex buffer bound 644
front-facing triangles 180	output window 105, 134, 137-8, 267
occluding points, potential 710	output XMVECTOR 53
occlusion 703, 705, 707, 710-11, 713, 715,	output ANY ECTOR 35 output controlpoints 476-7, 483, 591
722	outputtopology 476-7, 483, 591
average triangle 704	outputtopology 470-7, 403, 371
offset transform 775, 777-8	
offset transformation 775, 791	P
*	r
offset vectors 338, 710, 714	morphal light may: 297 290 00 672
OM see Output Merger	parallel light rays 287, 389-90, 673
OM stage 454, 566, 568, 666, 684, 721	parallel lights 287-9, 389-90, 666, 673,
one-by-one, texture animation frames 344	697
opacity 148, 183, 356, 621, 638-9, 654	parallelogram 34-5, 57, 72, 86-7
opaque 356, 361, 370, 381, 639	parameter passing 22, 32, 296
opaque scene objects 136	parameters
operations 2-3, 19, 27, 37, 97, 147, 170,	attenuation 270, 289
175, 204, 264, 343, 357, 429, 436, 737	

first 110-11, 115-16, 128, 210, 220,	pixel block colors 100
325, 377, 638, 641	pixel center 100-1, 422
second 111, 114-16, 201, 210, 220, 325,	pixel color
350, 638, 641, 681	final 150
particle system framework 640, 645, 647	lit 558
particle systems 90, 260, 429, 495-6, 631,	resolved 100
633, 635, 637-43, 645, 647-53, 655,	pixel colors 178, 265
657-61	object's 357
particles	pixel formats 89, 108
geometry shader inputs 642	pixel fragments 182, 207, 264, 357, 371,
geometry shader spawns/destroys/updates	375-6, 392, 394, 396-7
661	pixel nearest 674
living 645, 661	pixel shader 89-90, 150-1, 182-3, 203-5,
new 647, 652, 658	207-10, 213-14, 226, 263-4, 318-19,
struct 447, 633, 652, 657	361-2, 396-7, 422-4, 613-15, 686, 707-8
partitioning 476-7, 483, 493, 591	short 724
pass vertex color 203-5, 209-10, 214	simple 208
patch 203-3, 209-10, 214	pixel shader alpha 422
1	pixel shader body 415
grid of 607-8	•
40000lloted 470 402 501	pixel shader input 207, 209
tessellated 479, 493, 591	pixel shader input parameters 208
patch control points 473, 610, 616	pixel shader instructions 362
patch vertices, tessellated 493	pixel shader modifies 208, 396
patchconstantfunc 477-8, 483, 591	pixel shader stage 150, 182, 396, 399,
paused time 120-3	414-15, 423-4
track of 121	pixels
PCF (percentage closer filtering) 678,	changing 693
680-2, 686, 692-3, 695, 698-9	clipping 361-2
PCF kernel 682, 693-4	current 361, 370, 707
per-vertex materials 307	discard 362, 367, 412, 584, 690
percentage closer filtering see PCF	edge 422, 604
performance, peak 400	extra 464
performance counter 89, 116-19, 136	ijth 348, 371, 394, 450, 604
performance timer 116-17, 136	less 457
perspective projection 166, 627, 666-7,	neighbor 603-4, 718
672-3, 698-9	neighboring 100, 461, 604, 693
perspective projection matrix 173-4,	opaque 422
184-6, 507, 698	particular 95, 373, 392
picking 6, 71, 495, 520, 533-7, 539-41,	reject 373, 375, 392
543, 545-6, 698, 732, 735	rendering 361, 370
picking ray 533, 535-9, 541, 546	single 395, 632
ping-ponging vertex buffers 644	time processing 394
pipeline, rendering 89-90, 135, 141,	transparent 370, 685
149-53, 155-7, 163-5, 181-3, 189, 313,	visible 380, 383, 673-4, 698, 710, 720-1
430-1, 454-5, 471-3, 492, 529-30, 641-2	PixelShader 230, 232
pipeline stages 98-9, 104, 110, 313-14	plane
	•

bottom 521 complex 739-40	projection window 166-72, 182, 395, 533-5, 537, 546, 669-70
plane equations 521-2, 530-1, 616	projective texturing 669, 697
player 4, 116, 120-1, 455, 623, 626-7, 791	using 674, 688
PN triangles and Catmull-Clark	PS see Pixel Shader
approximations 493	_
PN triangles scheme 476	Q
point filtering 322-4, 678	1 1 00 454 5 450 04 404 400
point light source 288, 296, 388-9	quad patch 90, 474-5, 479-81, 491, 493,
point lights 90, 270, 288-91, 302-3, 308,	609
388-90, 699	cubic Bézier 484
point list 153-4, 265, 402	quad patch vertex 608
point primitives 407, 426, 632 point/vector 70, 74, 765	quad vertices 660, 708 quality levels 101-2, 108, 112, 125, 223-6
points, vanishing 142-3, 166, 183	quantities, vector-valued 4-5
polar representation 740-1, 746-7, 765	quaternion multiplication 743-5, 765
polygon slope 677	quaternion rotation operator 749, 751, 765
polygons, convex 177	quaternion space 765
position	quaternions 496, 519, 737-9, 741-5, 747,
given 563	749, 751, 753, 755-61, 763-7, 785
initial 634-5, 645, 661	interpolated 753, 756
particle 260, 447	nonzero 745, 765
standard 5-6, 18, 31, 85	QueryPerformanceCounter 117, 119-20,
vertex-blended 781	122
position element 191, 265, 397	using 117
position function 634	QueryPerformanceCounter function 117,
position vector 18, 67, 72, 83, 425, 506	136
ppImmediateContext 104-105	n
previous vertex shader 205-6, 782 primitive IDs 90, 414-16, 424, 426-7, 647	R
primitive fbs 90, 414-10, 424, 420-7, 047 primitive topologies 152-3	rain particles 645, 655
primitives, geometry shader outputs 640	random vectors 638, 709, 714
problem, depth buffer precision 173	random Values 637
product, vector-matrix 56	range parameter 289
program geometry shaders 90, 400	rasterization, depth/stencil buffer disables
programming geometry shaders 400	641
project vertices 253, 672	RAW format 601
projection 166-70, 172, 182, 206, 390,	ray casting 702-3, 706, 709, 722
507, 522, 533-4, 537, 666-7, 669, 697	ray direction 538, 541-2
projection frustum 522-3	ray intersects 533, 540-2, 546
projection matrix 127, 171-2, 174, 185-6,	ray misses 540-2, 546
206-7, 235, 501, 505, 522, 538, 669-70,	ray origin 538, 541-2, 703
682	ray/triangle intersection 516, 542, 705
orthographic 668-9, 698	real numbers 7, 30, 40, 45, 55, 737-8,
projection plane 167, 169, 667, 670, 697 projection transformation 171, 206	744-5, 753, 759, 765 properties of 33
projection transformation 171, 200	properties of 33

real part 738, 742, 748, 764, 766	bound 463-5
rectangles 88, 90, 178, 319, 616	random 709, 715-16
scissor 268	thread 449-50
red light 146-7, 271-2, 302, 308, 557	sample code 102, 118, 124
reference device 104-5, 125	sample count 102, 711
reference vectors 64	sample framework 108, 137, 423
reference vertices 184, 729	sample framework code 91
reflectance 281-2, 285, 290	sample neighboring values 694-5
reflection 182, 282, 284, 287, 371-2,	sample points, random 707, 709-10
378-81, 383-5, 557-8, 560, 562, 570,	sample texture 329, 362, 367, 412, 437,
596	584, 690
dynamic 455, 560	sampler 324-5, 638, 671, 724
specular 281-2	comparison 681
reflection vector 281-2, 284, 557-9	sampler states 325, 467
reflection vector per-pixel 557	Sampler State 324-5, 328, 334, 410, 439,
reinterpret 94, 99, 110, 134, 220, 235-6,	549, 555, 582, 610, 651, 657, 684, 688,
257-8, 262, 313, 373, 444, 454, 528,	712, 717
564-5, 721	sampling textures 324, 437, 449, 680
render-to-texture 450, 454, 664, 673	scalar multiplication 7-8, 24, 28, 32-3,
rendering effects 152, 212, 223, 263-4	39-40, 147-8, 744, 765
rendering pass 219, 264, 661	scaling 2-units 88
second 720	scaling matrix 62, 72, 81, 84-6, 161
rendering scene depth 664	scaling transformation 62, 277
representation, axis-angle rotation 759	scene, entire 94, 136, 394, 554, 567-8, 673,
resolution textures 321-2	682
resource, single 135	scene depth 664-5, 673-4, 698
resource bindings 230-1	scene geometry 246, 669
resource format 99, 314	scene lights 158, 307, 705
result, short distances 422	scene objects 136, 272, 302, 527, 533, 539
return codes 134	scene vertices 163, 498
RGB components 349, 369	screen normal/depth texture 724
RGBA color vector 352	screen pixels 322, 675
right-handed coordinate systems 6-7, 15	screen quad 455, 707-8
rotation matrices 65, 70, 83	screen resolution 100-1, 112, 457, 707,
rotation matrix 72, 84, 87, 161, 519, 751,	724
759-60, 765-6	screen space 181-2, 533, 535-6, 694-5,
general 84, 87	697, 702, 707
rotation transformation 71, 87	screen space ambient occlusion see SSAO
row vector-matrix multiplication 742	screen space triangle density 627
row vector-matrix indusplication 742 row vectors 40-2, 50, 65, 68, 71, 83, 162-3	SetBlendState 354, 655
RWTexture2D 433, 435-6, 438-9, 447,	SetComputeShader 434, 465
449-50, 463, 469	SetDepthStencilState 378, 556, 642, 653,
777-30, 703, 707	655, 659-60
S	SetRasterizerState 215, 266, 556, 685
U .	shader
sample	compiled 216, 218, 239
Sumpro	compiled 210, 210, 257

specialized 362, 368	shares 101, 212, 275-6, 422, 550, 578-9,
vertex/pixel 706	581, 590, 703-4, 734
shader code 216, 223, 225, 289, 362,	shear transform 187
366-7, 412, 448, 459, 463, 468, 584,	shell particles 647, 661-2
636, 645, 673	SIMD 19-22, 27, 32, 50-1, 432, 467
terrain pixel 622	SIMD instructions 19-20
shader function, constant hull 612, 627	size, wavefront 432, 434, 467
shader generator mechanism 226-7	sized triangles 403
shader input 193, 665, 697, 719	equal 252
control point hull 476, 493, 591	skin vertices 774
shader programs 212, 215, 220, 263, 284,	skinned mesh demo 776, 790, 792
336, 455, 460, 580, 605, 762	skull 145, 379-81, 383-4, 393, 397, 529,
shader resource 98-9, 113, 313-14, 317-18,	705, 720, 760, 763-4
327, 417, 430, 435, 553, 561-2, 568,	reflected 372, 379, 381-3
605, 607, 627, 665	slices 247, 249-51
corresponding 317-18	slope-scaled-bias 677, 698-9
shader variations 225-6, 264	smoke particles 639-40, 645
shades 146, 148, 213-14, 494	smoke textures 647
shadow, planar 90, 385-6, 388, 390, 496,	source, parallel light 287, 386-7
697	source alpha component 356, 358, 621
shadow acne 674-5, 698-9	source blend factor 348, 355-6
shadow cast 387, 389	source data 420
shadow edges 681-2, 698	source image 318, 340, 450
shadow factor 686-7	source pixels 347-8, 354-7, 361, 369
shadow map 664-6, 673-8, 681-2, 684-6,	space
688, 691, 693-9	cell 623-4
shadow map demo 691-2	homogeneous 177-8, 215, 388
shadow map samples 675, 679, 681-2	homogenous 522-3
shadow map stores 674, 697-8	positive half 177, 521
shadow map test 675, 678, 688, 693-4,	volume of 142, 166-7
696, 699	space coordinate system 499, 666
shadow map texel 674-5, 698	space coordinates 500, 668
shadow map texture space 688	space depth 706, 723
shadow map values 677, 679	space normals 706-7, 720
shadow mapping 455, 495-6, 663-5, 667,	space position 708, 710, 714
669, 671, 673, 675, 677, 679, 681-3,	space z-axis 501, 666-7, 697
685, 687, 689, 697	spaceship 144
shadow mapping algorithm, basic 663	specify DXGI 108
shadow matrix 388, 390, 392	specifying texture coordinates 326
general 390, 393	specular 281, 292-3, 558, 727
shadow plane 386, 388	specular light 270, 281-4, 308
shadowing techniques 223-4, 663	amount of 281-3, 285, 292
real-time 496, 697	specular term 296-8, 719-20
shared memory 431-2, 448-50, 461-2, 468,	sphere
716	lit 144, 269-70
shared memory array 449	unlit 144, 269-70

sphere intersects 524	specifying 571
sphere vertices box vertices cylinder vertices	surface point 278, 282, 285, 304-5, 307,
202	329, 362, 364-7, 370, 412, 554, 583,
spotlight 90, 270, 290-2, 298-9, 302-3,	672, 690
308, 672, 698-9	surface textures 476
spotlight cone 290-2, 672-3, 698	SV_DispatchThreadID 433, 437-9, 443,
spotlight factor 291, 298	446-7, 449-50, 463-4
square 63, 66, 69, 72, 84, 86, 162, 451,	SV_GroupID 445
<u> </u>	•
549, 554	SV_GroupThreedID 445 447 440 50
square matrices 48-9, 55	SV_GroupThreadID 445, 447, 449-50,
SSAO (screen space ambient occlusion)	463-4
455, 702, 706-7, 711, 715-16, 719-24	SV_InstanceID 510-11
SSAO map 707-8, 711, 715, 719-22, 724	SV_PrimitiveID 409, 411, 414-15, 423-4,
SSAO pixel shader 707-8	474, 477, 482-3, 590-1, 612, 619
SSE2 19-20, 26, 28, 30, 36, 53	SV_RenderTargetArrayIndex 566-7, 569
stacks 247-51, 420, 666	SV_TessFactor 474, 482, 590, 612
stage, clipping 183, 526, 529-30, 615	SWAP 103, 107-9, 132
stencil 90, 99, 371, 373	swap chain 94, 103, 107-10, 125, 136, 454
stencil buffer 90, 98, 130, 134, 210, 371-3,	switch 108, 131, 137, 212, 353, 362, 432,
375-6, 379-83, 386, 390-5	449, 455-6, 467-8, 716
8-bit 376-7	system
updated 380	rain particle 655
stencil buffer entry 376-7, 380, 390	three-point lighting 306
corresponding 381, 391, 394	system memory 112, 196, 242, 261, 417,
stencil buffer operation 395	430, 442-3, 540, 732, 735
stencil buffer pixels 380, 390	system memory buffer 442-3
stencil buffer tests 182, 207	system memory copy 514, 520, 540, 732,
stencil buffer to prevent double blending	735
390	system memory resource 442
stencil buffer value 390	system values 204, 468, 566
stencil test 210, 373-7, 380-1, 390-2	
strips 154-5, 401-2, 405	T
<del>-</del>	
structure	
structure output vertex type 400	tangent 576, 578, 580, 614-15, 730, 781,
	tangent 576, 578, 580, 614-15, 730, 781, 783
output vertex type 400	783
output vertex type 400 special resource 195, 200, 263	783 tangent plane 273, 304, 307, 694
output vertex type 400 special resource 195, 200, 263 structured buffer resources 439 structured buffers 197, 439-40, 442-3,	783 tangent plane 273, 304, 307, 694 tangent space 577-81, 594, 614
output vertex type 400 special resource 195, 200, 263 structured buffer resources 439 structured buffers 197, 439-40, 442-3, 447-8, 467-8	783 tangent plane 273, 304, 307, 694 tangent space 577-81, 594, 614 tangent vectors 276, 304-5, 326, 487, 576,
output vertex type 400 special resource 195, 200, 263 structured buffer resources 439 structured buffers 197, 439-40, 442-3, 447-8, 467-8 subdivide 252-3, 402, 405, 425, 586, 611	783 tangent plane 273, 304, 307, 694 tangent space 577-81, 594, 614 tangent vectors 276, 304-5, 326, 487, 576, 578-9, 581-2, 614-15, 694
output vertex type 400 special resource 195, 200, 263 structured buffer resources 439 structured buffers 197, 439-40, 442-3, 447-8, 467-8 subdivide 252-3, 402, 405, 425, 586, 611 subpixels 100-1, 112, 422	783 tangent plane 273, 304, 307, 694 tangent space 577-81, 594, 614 tangent vectors 276, 304-5, 326, 487, 576, 578-9, 581-2, 614-15, 694 per-vertex 581
output vertex type 400 special resource 195, 200, 263 structured buffer resources 439 structured buffers 197, 439-40, 442-3, 447-8, 467-8 subdivide 252-3, 402, 405, 425, 586, 611 subpixels 100-1, 112, 422 visible 100-1	783 tangent plane 273, 304, 307, 694 tangent space 577-81, 594, 614 tangent vectors 276, 304-5, 326, 487, 576, 578-9, 581-2, 614-15, 694 per-vertex 581 transformed 276
output vertex type 400 special resource 195, 200, 263 structured buffer resources 439 structured buffers 197, 439-40, 442-3, 447-8, 467-8 subdivide 252-3, 402, 405, 425, 586, 611 subpixels 100-1, 112, 422 visible 100-1 subrectangle 115-16, 139, 267	783 tangent plane 273, 304, 307, 694 tangent space 577-81, 594, 614 tangent vectors 276, 304-5, 326, 487, 576, 578-9, 581-2, 614-15, 694 per-vertex 581 transformed 276 target array slice 566, 569
output vertex type 400 special resource 195, 200, 263 structured buffer resources 439 structured buffers 197, 439-40, 442-3, 447-8, 467-8 subdivide 252-3, 402, 405, 425, 586, 611 subpixels 100-1, 112, 422 visible 100-1 subrectangle 115-16, 139, 267 supersampling 100-1	783 tangent plane 273, 304, 307, 694 tangent space 577-81, 594, 614 tangent vectors 276, 304-5, 326, 487, 576, 578-9, 581-2, 614-15, 694 per-vertex 581 transformed 276 target array slice 566, 569 target point 165-6
output vertex type 400 special resource 195, 200, 263 structured buffer resources 439 structured buffers 197, 439-40, 442-3, 447-8, 467-8 subdivide 252-3, 402, 405, 425, 586, 611 subpixels 100-1, 112, 422 visible 100-1 subrectangle 115-16, 139, 267 supersampling 100-1 surface, smooth 281, 284, 476, 493, 578	783 tangent plane 273, 304, 307, 694 tangent space 577-81, 594, 614 tangent vectors 276, 304-5, 326, 487, 576, 578-9, 581-2, 614-15, 694 per-vertex 581 transformed 276 target array slice 566, 569 target point 165-6 TBN-bases 576, 579-81, 593
output vertex type 400 special resource 195, 200, 263 structured buffer resources 439 structured buffers 197, 439-40, 442-3, 447-8, 467-8 subdivide 252-3, 402, 405, 425, 586, 611 subpixels 100-1, 112, 422 visible 100-1 subrectangle 115-16, 139, 267 supersampling 100-1	783 tangent plane 273, 304, 307, 694 tangent space 577-81, 594, 614 tangent vectors 276, 304-5, 326, 487, 576, 578-9, 581-2, 614-15, 694 per-vertex 581 transformed 276 target array slice 566, 569 target point 165-6

billboard 423	vertices header 730, 783
multi-pass 213, 264	texture alpha 362, 367, 412, 584, 690
multi-texturing 496	texture animation 311, 338
multiple 223	texture array 90, 112, 400, 414-21, 424,
render-to-texture 454	510-11, 548, 553, 560-1, 568-9, 622,
rendering 189, 213, 264, 641-2, 648,	647, 651, 656
650, 661	entire 565-6
technique objects 219	texture array index 420
terragen 551, 569, 600-1, 628	texture array stores 415, 424
terrain 213, 240, 246, 299, 347, 495-6,	texture artists 316, 587
556, 597-603, 605-9, 611, 613, 615, 617,	texture atlas 316, 319, 344
619-23, 625-9	texture buffers 94, 456
void 601, 605, 608-9, 617	texture color 323, 325, 639
terrain color, current 621	texture coordinate offset value 637
terrain demo 628	texture coordinate system 314-15, 697
terrain grid, tessellated 607	texture coordinate transformations 336
terrain layers 620	texture coordinates
terrain mesh geometry 623, 627	compressed 575
terrain surface 304, 597, 599, 623-4, 626-8	corresponding 316, 577
terrain tessellation 606, 627	generated 669
terrain vertex 623, 627	generating projective 669, 671
terrain vertex shader 610	interpolated 320, 326
tessellate 90, 471-2, 474-6, 478, 481, 483,	normal 672
492-3, 572, 585, 588-9, 593, 607, 627,	normalized 320, 438
686, 721	pair of 316, 320
tessellated geometry 686, 721	projective 669, 671-2, 678, 697, 710,
tessellating 253, 425, 474-6, 481, 483, 493	719
tessellation 90, 175, 251-2, 264, 471-3,	respective 315, 345
475-81, 483-4, 492-3, 496, 571, 585,	transforming 332
587-9, 592, 611, 613	unbounded 636
fractional 477, 493	unique 320
tessellation factors 474-9, 481, 492-3,	using 438
588-91, 608, 611-12, 615, 627, 629	texture data 317, 327, 551, 639
interior 475, 478-9, 590-1, 611	texture dimensions 314, 318
tessellation stages 90, 156, 175, 183, 399,	texture distortion 316, 578
423, 471-9, 481, 483, 485, 487, 489,	texture elements 415-18, 467
491-3, 526, 530	texture files 341, 576
tessellator 480, 484, 492, 572, 592	texture filtering 548, 622
ray/triangle 540	texture format 101-2
scissor 268	texture function 332-3
test scene 397, 426	texture functionality 262, 697
tex-coords 248, 469, 713, 730, 783	texture geometry 436
texel points 319-21	texture image 437, 572, 574
texel values 461-2	entire 316, 326
text	texture map 316, 319, 322, 325, 369, 573,
triangles header 731	575, 615, 637, 709

random vector 710	extraneous 458, 462, 466
texture mapping 90, 286, 311, 316, 571, 576	main rendering 106-7 worker 106-7
texture matrix 336, 671	thumb points 6-7, 16
water's 338	time 116-23, 129-30, 136-7, 160-1, 222,
texture objects 312, 318, 344	225-6, 259-61, 565-9, 633-5, 637,
texture outputs and unordered access 435	643-7, 661, 760-1, 776-7, 785-6
texture plane 332, 335, 338, 574, 577	current 120-2
texture resolution 333, 336	function of 121, 266, 335-6, 338, 344,
texture resources 98, 150, 260, 264, 313,	425, 771
317-19, 434, 467, 734	initialization 99, 212, 218, 254, 260,
texture samples 449, 680	313, 322, 325, 327, 420
reducing 454	real number 738, 744
texture size 438	total 120-1, 123
texture space 315-16, 337, 576-9, 593,	time intervals 116, 137
669-71, 683	time position 764, 785, 789-90
texture space axes 576-7	timer 116, 121-2, 130
texture space coordinates 337	to-far-plane vectors 708
texture space plane 338	interpolated 707-8
texture space v-axis 614	to-parent transform 773, 791
texture stores 93, 312, 415	transform 69-70, 178-9, 203-6, 209-10,
texture subresources 420	299-300, 329, 332, 366, 404, 527-8,
texture tiling 90, 338	580-1, 593-4, 771-8, 781-2, 791
texture transform 671	transform coordinates 2, 579
texture transformation matrix 338, 594	transform geometry 772
texture transformations 596	transform quad vertices 412, 655
animated 90	transformation matrices 59, 83, 158
texture triangle 316, 576	constructing 59
texture values 322, 449	creating multiple world 246
texture vertex 316	transformation matrix 70, 80, 83, 86, 276
Texture2D 111, 318, 324-5, 327-8, 340,	336, 504, 546, 762, 772
418, 433, 435-6, 438-9, 447, 449-50,	affine 68, 71, 185-6
560-3, 605-6, 665, 687-8	net 59, 72
TextureCube 548-9, 553-5, 560-2, 568,	single 84
582, 688	to-parent 773, 791
texturing 90, 112, 152, 241, 305, 322-3,	translation affine 80
328, 331, 368, 548, 556, 602, 647, 651,	transformations 1-2, 59, 61, 63, 65, 67,
656	69-75, 77-88, 158-9, 164, 167, 171-3,
texturing coordinate system 576	187, 277-8, 771-2
thread group sizes 432, 445, 459	active 80-1, 83
thread groups 432-4, 437, 443, 445-6,	body 71, 576
448-9, 456-61, 464, 467-8	change-of-coordinate 499, 770
thread ID values 447	final 775, 780, 792
thread IDs 431, 437, 445-7, 468	identity 68
threads 430, 432-4, 437, 443, 445-50,	reverse 164, 498
458-62, 464-5, 467-8	rotation texture 594

sequence of 161-3	triangle patch configurations 475
texture space 670	triangle patch tessellation examples 479
to-root 775, 791-2	triangle plane 586
transformed point 71-2, 781	triangle shares 276
transformed tangent vector 276	triangle strip 154-5, 157, 265, 401-2, 412
associated 276	655
TransformFrustum 528	using 153
transforming normal vectors 276	triangle strip vertices 411, 654
transforming normals 781-2	triangle subdivisions 479
transitions, smooth 285, 308, 422, 597	triangle-to-triangle 577
translation 2, 37, 59, 67-8, 70-1, 73-4,	triangle topology 262
80-2, 85, 88, 164, 187, 278, 624-5, 761,	triangle vertex 542
763	triangle vertices 179, 425, 577-8
translation matrix 69, 72, 81, 84-5, 87,	triangles
162, 187, 278	acute angled 316
translation transformations 68, 81	additional 586
transparency 90, 180, 182, 270, 348, 356,	adjacent 155-6, 591
381, 384, 386, 390, 422, 640, 729	back-facing 180, 211
transparency alpha 620-1	bottom 590
transpose 37, 43, 47, 54-6, 58, 65, 83, 580,	clipped 177, 530
742, 751	corresponding 315
traverse 725, 769, 773, 775, 778-9	discards 526, 530
tree billboard demo 408-9, 422-3	extra 175
trees 143, 405, 416, 422-3, 727, 775, 778	facing 376-7
triangle centroid 591	flattened 390
triangle clipping 475	front-facing 211
triangle count 90, 471, 481	group of 728, 735
low 175	left 179
triangle density 247, 627	lower 624-5
triangle duplicates 157	mapped 576
triangle grid 469, 598	neighboring 156
triangle grid mesh 240, 260	new 175, 483
triangle grid mesh vertices 260	ordinary 476
triangle indices 730	overlapping 390
triangle input 425	picked 540, 544-5
triangle lists 145, 153, 155-7, 176, 265,	right 179
399, 402	right angled 316
using 153, 156	slice 250
triangle mesh 145, 183, 273-5, 285, 287,	subdivided 402
307-8, 473, 476, 541, 546, 587, 623, 627	tessellated 475
arbitrary 308, 579	top 405, 590
using arbitrary 581	translating 425
triangle mesh approximation 145	upper 624-5
triangle patch 473, 475-6, 480, 493, 588	using 252
cubic Bézier 476	triangles form 145
order cubic Bézier 476	triple buffering 94, 108

trivial access function 126	vector properties 33, 67
typeless formats 94, 99, 135, 313-14	vector reflection function 296
	vector subtraction 8, 28
U	vectors
	32-bit float 191
UAV (Unordered Access Views) 435-6,	bitangent 579
440-2, 448, 456-7, 467-8	column 38, 40-1
unit direction vector 635	coordinate 61
unit length 10, 12-14, 65, 83, 87, 249, 278,	displacement 68, 71
305, 425, 504, 531, 541-2, 578-9, 723,	distributed 709-10
753	first 15-16, 295
unit quaternions 496, 519, 522, 737, 745-7,	incident 284, 569-70
749-50, 753, 755, 757-8, 760, 765-6	incoming light ray 570
unit sphere 252-3, 404, 425, 636, 638, 652,	ith column 543, 754
657, 753-4, 756-9	jth column 40, 55
unordered access views see UAV	lookup 548-9, 554, 557, 568
UNORM depth buffer format 677	normalized 30, 448
UNORM format 109, 138, 340-1, 678	orthogonal 12, 17, 34
updating 112, 196, 207, 262, 408, 420, 645	orthogonal set of 13-14
upper triangle ABC 626	orthonormal 18, 507
	orthonormal axis 531
$\mathbf{V}$	returned 16, 27
	right 502-4, 507
valid depth/stencil buffer formats 392	signed integer 191
valleys 246, 260, 597-8, 627	texture coordinate 336
values	transform 278, 539
approximate 320	transforming 82, 580, 751
decremented 377	translation 67, 785
incremented 376-7	unsigned integer 191
maximum 376-7	using 18-19
random 637	vectors and coordinate systems 5
stencil 383-4	velocities 2, 4, 447, 634-5, 641, 645, 652,
variables, second constant buffer stores scene	658, 661
light 207	vertex
vector addition 7-8, 19, 24, 28, 32, 739	arbitrary 275, 578-9
geometric interpretation of 8, 625	first 200, 203, 255
vector coordinates 6, 67, 215	generated 608, 613
lookup 551	ijth 337, 598, 603, 627
vector dot product function 296	last 249-50
vector functions 26	middle 275
vector-matrix multiplications 37, 42, 61,	object's 160
72-3, 78, 205	particular 598, 627
vector operations 18, 26, 32-3, 147, 183	upper-left 623-4
vector part 747-8	vertex arrays 156, 255
imaginary 742, 744, 764	vertex attributes 181, 204, 705-6
vector/point 76, 83	vertex basis 263, 285
· ′	,

vertex blend weights 783	tessellated 479, 613
vertex buffer storing 481, 491	vertex shader, simple 203
vertex buffers 152-3, 156, 195-202, 210,	vertex shader acts 479, 493
237, 242, 255-6, 261-3, 265, 513, 520,	vertex shader body 415
640-5, 647-9, 661	vertex shader fragment 781
array of 199, 643	vertex shader function 158
concatenated 255	vertex shader input parameters 204
corresponding 199	vertex shader input signature 190, 193
corresponding local 201-2	vertex shader output 209
dynamic 260, 262, 408, 645	vertex shader parameters 204, 208
global 202-3	vertex shader signature 415, 424
immutable 197	vertex shader stage 158
initialization 647-8	vertex shader structure order, corresponding
ith 199	267
large 202, 266	vertex shaders, discussed 213
special initialization 647	vertex structure 158, 190-4, 204, 223, 225
start binding 199	263-4, 266-7, 285, 316, 408, 519, 579,
static 408	633, 780
using 199	custom 193, 204
<u> </u>	terrain patch 608
2 3	vertex structure order 267
<u> </u>	
vertex colors 197, 270, 285, 301	vertex texture coordinates 316, 320, 345
vertex component 192, 263	vertex type 198, 401
vertex data 153, 156-7, 176, 190-1, 199,	vertex vertices 198, 237
242, 263, 326, 511-13, 643	vertical field 168-9, 174, 184-5, 187, 502,
vertex depth values 181	522, 537
vertex elements 191, 204, 208, 244, 256,	vertices
512	array of 195, 275, 401, 520
vertex formats 152, 190, 307, 641, 730	duplicate 157
custom 190, 263	generated 90, 471, 481, 592, 607, 627
vertex heights change 262	list of 152, 399, 401-2
vertex IDs 415, 424, 426-7	maximum number of 400
vertex/index buffers 156, 261	new 252, 262, 403, 424, 477
static 540	object's 386, 388
vertex index values 415, 424, 426-7	outgoing 401, 414
vertex input layout 239, 644	tessellated 586
vertex level 287, 301, 571	unique 157-8, 247
vertex lighting calculation 273	vertex shader inputs 399
vertex list 157-8, 184, 193, 399, 520, 640,	vertices and triangle indices 730
644, 661	vertices output 402, 640, 661
vertex normals 273-4, 276, 287, 305, 308,	viewer 94-8, 136, 142-3, 163, 179, 181,
426, 494, 578	271-2, 303, 423
vertex points 273-4, 305, 308	viewpoint 179, 280-1, 550, 563, 664-5,
vertex positions 176, 204-5, 399, 480, 494,	673, 675
586, 613, 682	viewport 103, 115-16, 125, 178-9, 267,
first sphere 203	535, 562, 564, 664, 666, 721

viewport matrix 535-6	XM_NO_OPERATOR_OVERLOADS
virtual camera 18, 89, 141, 150, 163, 183	24, 51
vM, vector-matrix product 82	XMCOLOR 21-2, 149-50, 183, 264, 266-7
	XMColorModulate 148
$\mathbf{W}$	XMConvertToDegrees 25, 29
	XMConvertToRadians 25, 236, 506, 763
w-coordinate, negative 388	XMFLOAT 21
wall 272, 281, 320, 322, 335, 358, 372,	XMFLOAT2 20-1
379-80, 383, 393	XMFLOAT3 20-1
water 240, 303, 305, 336, 347, 369-70,	XMFLOAT4 20-1
469, 570	XMFLOAT4X4 51
water geometry 336, 338	XMLoadByte4 21
water pixels 347, 370	XMLoadColor 21, 149
water texture 336, 338	XMMATRIX ViewProj 257, 500, 506
waves 260, 262, 303, 455, 469, 594-6	XMMATRIX world 220, 236, 258, 383,
waves demo 261-2, 299, 336	392
waves vertex shader 469	XMMATRIX class 50
weights 85, 275, 366, 451-3, 558, 715,	XMMatrixAffineTransformation 761-2
718, 753, 780-2, 784	XMMatrixDecompose 528
winding order 155-6, 181, 384, 477	XMMatrixDeterminant 53, 277, 528
wireframe 211, 215, 425, 586	XMMatrixIdentity 52-3, 234, 254
work	XMMatrixInverse 52-53, 277, 523, 528,
common 226-7	539
computation 449-50	XMMatrixIsIdentity 52
specialized 263-4	XMMatrixLookAtLH 166, 235, 683
world, combined 206-7	XMMatrixMultiply 52
world coordinate system 160, 163-4, 184,	XMMatrixPerspectiveFovLH 174, 235,
499, 507, 772, 774	457, 502
world coordinates 499, 507, 580, 632	XMMatrixReflect 837
world matrices 254, 514	XMMatrixRotationAxis 81, 503
world matrix 159, 161-4, 206, 246, 254,	XMMatrixRotationAxis function 503
388, 407, 499, 510-12, 530, 539, 577,	XMMatrixRotationX 81
580, 654	XMMatrixRotationY 81, 503, 683
skull's 764	XMMatrixRotationZ 81
world space axes 507, 549-50	XMMatrixScaling 81, 254, 338-9
world space coordinates 163, 549, 580	XMMatrixScalingFromVector 81
world space float 215	XMMatrixShadow 390, 392
world transform 159-60, 163, 388, 511,	XMMatrixTranslation 81, 254-5, 339, 392
520, 773	XMMatrixTranslationFromVector 81
world transformation matrix 266	XMMatrixTranspose 52-3
world-view-projection matrix, combined	XMPlaneDotCoord 831
220	XMPlaneDotNormal 831
world y-axis 165, 503	XMPlaneFromPointNormal 831
- -	XMPlaneFromPoints 832
X	XMPlaneIntersectLine 834, 838

XMPlaneNormalize 832-3

XMPlaneTransform XMQuaternionConjugate 759 XMQuaternionIdentity 759 XMQuaternionLength 759 **XMQuaternionMultiply** 759 XMQuaternionNormalize 759 **XMQuaternionRotationAxis** 759, 763 XMQuaternionRotationNormal 759 XMOuaternionSlerp 760, 762 XMStoreByte4 XMStoreColor 22, 150 26, 28, 35, 53, 249, 253-4, XMStoreFloat 303, 305, 384, 503-4, 518, 616, 683, 710, 763 XMStoreFloat2 21 XMStoreFloat3 21 XMStoreFloat4 21 XMStoreFloat4x4 234-5, 254-5, 338-9, 457, 502, 683, 761-2, 778-9 XMStoreInt3 22 XMVector3AngleBetweenVectors XMVector3ComponentsFromNormal 29 XMVector3Cross 27-8, 32, 249, 504, 704 27-8, 32, 504 XMVector3Dot XMVector3Equal 27, 29 XMVector3Length 27-8, 30, 32 XMVector3LengthSq 27, 32, 636 XMVector3NearEqual\_function XMVector3Normalize 27-8, 30, 32, 249, 253-4, 303, 305, 504, 539, 636, 704 XMVector3NotEqual 27, 29 XMVector3Orthogonal 27 XMVector3Transform 82 XMVector3TransformCoord 82, 539, 683 XMVector3TransformNormal 82, 384, 503, 539, 683 XMVectorReplicate 25-6, 503 XMVectorSet 25-6, 28, 30, 36, 166, 235, 277, 303, 383, 392, 538, 636, 683, 761-3 XMVectorSplatOne 25-6 XNA collision library 517, 519, 521-2, 524, 526, 541 XNA collision library functions 519-20, 541

20-1, 25-6, 50, 81, 759

XNA math

XNA math library 1, 19-20, 24, 30-2, 52, 59, 148-50, 166, 183, 390, 531, 759
XNA math library's vector functions 3
XNA math not supported 26, 28, 30, 36, 53
XNA math vector functions 148, 183
XNA model class 725