OpenGL 4.00 API Quick Reference Card

OpenGL® is the only cross-platform graphics API that enables developers of software for PC, workstation, and supercomputing hardware to create high-performance, visually-compelling graphics software applications, in markets such as CAD, content creation, energy, entertainment, game development, manufacturing, medical, and virtual reality.
Specifications are available at www.opengl.org/registry

- *see FunctionName* refers to functions on this reference card.
- Content shown in blue is removed from the OpenGL 4.00 core profile and present only in the OpenGL 4.00 compatibility profile. Profile selection is made at context creation.
- **[n.n.n]** and **[Table n.n]** refer to sections and tables in the OpenGL 4.00 core specification.
- **[n.n.n]** and **[Table n.n]** refer to sections and tables in the OpenGL 4.00 compatibility profile specification, and are shown only when they differ from the core profile.
- **[n.n.n]** refers to sections in the OpenGL Shading Language 4.00 specification.

OpenGL Operation

Floating-Point Numbers [2.1.1 - 2.1.4]

16-Bit	1-bit sign, 5-bit exponent, 10-bit mantissa
Unsigned 11-Bit	no sign bit, 5-bit exponent, 6-bit mantissa
Unsigned 10-Bit	no sign bit, 5-bit exponent, 5-bit mantissa

Command Letters [Table 2.1]

Letters are used in commands to denote types.

b - byte (8 bits)	**ub** - ubyte (8 bits)
s - short (16 bits)	**us** - ushort (16 bits)
i - int (32 bits)	**ui** - uint (32 bits)
i64 - int64 (64 bits)	**ui64** - uint64 (64 bits)
f - float (32 bits)	**d** - double (64 bits)

GL Command Syntax [2.3]

GL commands are formed from a return type, a name, and optionally up to 4 characters (or character pairs) from the Command Letters table (above), as shown by the prototype below:

return-type **Name**{1234}{b s i i64 f d ub us ui ui64}{v} ([*args* ,] *T arg1* , . . . , *T argN* [, *args*]);

The arguments enclosed in brackets ([args ,] and [, args]) may or may not be present.
The argument type T and the number N of arguments may be indicated by the command name suffixes. N is 1, 2, 3, or 4 if present, or else corresponds to the type letters from the Command Table (above). If "v" is present, an array of N items are passed by a pointer.

For brevity, the OpenGL documentation and this reference may omit the standard prefixes. The actual names are of the forms:

glFunctionName(), GL_CONSTANT, GLtype

Vertex Arrays [2.8]

Vertex data may be placed into arrays stored in the client address space or server address space.

void **VertexPointer**(int *size*, enum *type*, sizei *stride*, void **pointer*);
type: SHORT, INT, FLOAT, HALF_FLOAT, DOUBLE, INT_2_10_10_10_REV, UNSIGNED_INT_2_10_10_10_REV

void **NormalPointer**(enum *type*, sizei *stride*, void **pointer*);
type: *see VertexPointer*, plus BYTE

void **ColorPointer**(int *size*, enum *type*, sizei *stride*, void **pointer*);
type: *see VertexPointer*, plus BYTE, UBYTE, USHORT, UINT

void **SecondaryColorPointer**(int *size*, enum *type*, sizei *stride*, void **pointer*);
type: *see ColorPointer*

void **IndexPointer**(enum *type*, sizei *stride*, void **pointer*);
type: UBYTE, SHORT, INT, FLOAT, DOUBLE

void **EdgeFlagPointer**(sizei *stride*, void **pointer*);

void **FogCoordPointer**(enum *type*, sizei *stride*, void **pointer*);
type: FLOAT, HALF_FLOAT, DOUBLE

void **TexCoordPointer**(int *size*, enum *type*, sizei *stride*, void **pointer*);
type: *see VertexPointer*

void **VertexAttribPointer**(uint *index*, int *size*, enum *type*, boolean *normalized*, sizei *stride*, const void **pointer*);
type: *see ColorPointer*

void **VertexAttribIPointer**(uint *index*, int *size*, enum *type*, sizei *stride*, const void **pointer*);
type: BYTE, UBYTE, SHORT, USHORT, INT, UINT
index: [0, MAX_VERTEX_ATTRIBS - 1]

void **EnableClientState**(enum *array*);

void **DisableClientState**(enum *array*);
array: VERTEX_ARRAY, NORMAL_ARRAY, COLOR_ARRAY, SECONDARY_COLOR_ARRAY, INDEX_ARRAY, EDGE_FLAG_ARRAY, FOG_COORD_ARRAY, TEXTURE_COORD_ARRAY

void **EnableVertexAttribArray**(uint *index*);

void **DisableVertexAttribArray**(uint *index*);
index: [0, MAX_VERTEX_ATTRIBS - 1]

void **VertexAttribDivisor**(uint *index*, uint *divisor*);

void **ClientActiveTexture**(enum *texture*);
index: TEXTURE*i* (where *i* is [0, MAX_TEXTURE_COORDS - 1])

void **ArrayElement**(int *i*);

Enable/Disable(PRIMITIVE_RESTART)

void **PrimitiveRestartIndex**(uint *index*);

Drawing Commands [2.8.2] [2.8.3]

void **DrawArrays**(enum *mode*, int *first*, sizei *count*);

void **DrawArraysInstanced**(enum *mode*, int *first*, sizei *count*, sizei *primcount*};

void **DrawArraysIndirect**(enum *mode*, const void **indirect*);

void **MultiDrawArrays**(enum *mode*, int **first*, sizei **count*, sizei *primcount*);

void **DrawElements**(enum *mode*, sizei *count*, enum *type*, void **indices*);

void **DrawElementsInstanced**(enum *mode*, sizei *count*, enum *type*, const void **indices*, sizei *primcount*);

void **MultiDrawElements**(enum *mode*, sizei **count*, enum *type*, void ***indices*, sizei *primcount*);

void **DrawRangeElements**(enum *mode*, uint *start*, uint *end*, sizei *count*, enum *type*, void **indices*);

void **DrawElementsBaseVertex**(enum *mode*, sizei *count*, enum *type*, void **indices*, int *basevertex*);

void **DrawRangeElementsBaseVertex**(enum *mode*, uint *start*, uint *end*, sizei *count*, enum *type*, void **indices*, int *basevertex*);

void **DrawElementsInstancedBaseVertex**(enum *mode*, sizei *count*, enum *type*, const void **indices*, sizei *primcount*, int *basevertex*);

void **DrawElementsIndirect**(enum *mode*, enum *type*, const void **indirect*);

void **MultiDrawElementsBaseVertex**(enum *mode*, sizei **count*, enum *type*, void ***indices*, sizei *primcount*, int **basevertex*);
mode: POINTS, LINE_STRIP, LINE_LOOP, LINES, POLYGON, TRIANGLE_STRIP, TRIANGLE_FAN, TRIANGLES, QUAD_STRIP, QUADS, LINES_ADJACENCY, LINE_STRIP_ADJACENCY, PATCHES, TRIANGLES_ADJACENCY, TRIANGLE_STRIP_ADJACENCY
type: UNSIGNED_BYTE, UNSIGNED_SHORT, UNSIGNED_INT

void **InterleavedArrays**(enum *format*, sizei *stride*, void **pointer*);
format: V2F, V3F, C4UB_V2F, C4UB_V3F, C3F_V3F, N3F_V3F, C4F_N3F_V3F, T2F_V3F, T4F_V4F, T2F_C4UB_V3F, T2F_C3F_V3F, T2F_N3F_V3F, T2F_C4F_N3F_V3F, T4F_C4F_N3F_V4F

Buffer Objects [2.9]

void **GenBuffers**(sizei *n*, uint **buffers*);
void **DeleteBuffers**(sizei *n*, const uint **buffers*);

Creating and Binding Buffer Objects [2.9.1]

void **BindBuffer**(enum *target*, uint *buffer*);
target: ARRAY_BUFFER, COPY_{READ, WRITE}_BUFFER, DRAW_INDIRECT_BUFFER, ELEMENT_ARRAY_BUFFER, PIXEL_PACK_BUFFER, PIXEL_UNPACK_BUFFER, TEXTURE_BUFFER, TRANSFORM_FEEDBACK_BUFFER, UNIFORM_BUFFER

void **BindBufferRange**(enum *target*, uint *index*, uint *buffer*, intptr *offset*, sizeiptr *size*);
target: TRANSFORM_FEEDBACK_BUFFER, UNIFORM_BUFFER

void **BindBufferBase**(enum *target*, uint *index*, uint *buffer*);
target: *see BindBufferRange*

Creating Buffer Object Data Stores [2.9.2]

void **BufferData**(enum *target*, sizeiptr *size*, const void **data*, enum *usage*);
usage: STREAM_{DRAW, READ, COPY}, STATIC_{DRAW, READ, COPY}, DYNAMIC_{DRAW, READ, COPY}
target: *see BindBuffer*

void **BufferSubData**(enum *target*, intptr *offset*, sizeiptr *size*, const void **data*);
target: *see BindBuffer*

Mapping/Unmapping Buffer Data [2.9.3]

void ***MapBufferRange**(enum *target*, intptr *offset*, sizeiptr *length*, bitfield *access*);
access: The logical OR of MAP_{READ, WRITE}_BIT, MAP_INVALIDATE_{BUFFER, RANGE}_BIT, MAP_FLUSH_EXPLICIT_BIT, MAP_UNSYNCHRONIZED_BIT
target: *see BindBuffer*

void ***MapBuffer**(enum *target*, enum *access*);
access: READ_ONLY, WRITE_ONLY, READ_WRITE

void **FlushMappedBufferRange**(enum *target*, intptr *offset*, sizeiptr *length*);
target: *see BindBuffer*

boolean **UnmapBuffer**(enum *target*);
target: *see BindBuffer*

Copying Between Buffers [2.9.5]

void ***CopyBufferSubData**(enum *readtarget*, enum *writetarget*, intptr *readoffset*, intptr *writeoffset*, sizeiptr *size*);
readtarget and *writetarget:* *see BindBuffer*

Vertex Array Objects [2.10]

All states related to definition of data used by vertex processor is in a vertex array object.

void **GenVertexArrays**(sizei *n*, uint **arrays*);
void **DeleteVertexArrays**(sizei *n*, const uint **arrays*);
void **BindVertexArray**(uint *array*);

Buffer Object Queries [6.1.9] [6.1.15]

boolean **IsBuffer**(uint *buffer*);

void **GetBufferParameteriv**(enum *target*, enum *pname*, int **data*);
target: *see BindBuffer*
pname: BUFFER_SIZE, BUFFER_USAGE, BUFFER_ACCESS{_FLAGS}, BUFFER_MAPPED, BUFFER_MAP_{OFFSET, LENGTH}

void **GetBufferParameteri64v**(enum *target*, enum *pname*, int64 **data*);
target: *see BindBuffer*
pname: *see GetBufferParameteriv*,

void **GetBufferSubData**(enum *target*, intptr *offset*, sizeiptr *size*, void **data*);
target: *see BindBuffer*

void **GetBufferPointerv**(enum *target*, enum *pname*, void ***params*);
target: *see BindBuffer*
pname: BUFFER_MAP_POINTER

Vertex Array Object Queries [6.1.10] [6.1.16]

boolean **IsVertexArray**(uint *array*);

Vertex Specification

Begin and End [2.6]

Enclose coordinate sets between Begin/End pairs to construct geometric objects.

void **Begin**(enum *mode*);
void **End**(void);
mode: *see MultiDrawElementsBaseVertex*

Separate Patches

void **PatchParameteri**(enum *pname*, int *value*);
pname: PATCH_VERTICES

Polygon Edges [2.6.2]

Flag each edge of polygon primitives as either boundary or non-boundary.

void **EdgeFlag**(boolean *flag*);
void **EdgeFlagv**(boolean **flag*);

Vertex Specification [2.7]

Vertices have two, three, or four coordinates, and optionally a current normal, multiple current texture coordinate sets, multiple current generic vertex attributes, current color, current secondary color, and current fog coordinates.

void **Vertex{234}{sifd}**(T *coords*);
void **Vertex{234}{sifd}v**(T *coords*);
void **VertexP{234}ui**(enum *type*, uint *coords*)
void **VertexP{234}uiv**(enum *type*, uint **coords*)
type: INT_2_10_10_10_REV, UNSIGNED_INT_2_10_10_10_REV
void **TexCoord{1234}{sifd}**(T *coords*);
void **TexCoord{1234}{sifd}v**(T *coords*);
void **TexCoordP{1234}ui**(enum *type*, uint *coords*)
void **TexCoordP{1234}uiv**(enum *type*, uint **coords*)
type: *see VertexP{234}uiv*
void **MultiTexCoord{1234}{sifd}**(enum *texture*, T *coords*)
void **MultiTexCoord{1234}{sifd}v**(enum *texture*, T *coords*)
texture: TEXTURE*i* (where *i* is [0, MAX_TEXTURE_COORDS - 1])
void **MultiTexCoordP{1234}ui**(enum *texture*, enum *type*, uint *coords*)
void **MultiTexCoordP{1234}uiv**(enum *texture*, enum *type*, uint **coords*)

void **Normal3{bsifd}**(T *coords*);
void **Normal3{bsifd}v**(T *coords*);
void **NormalP3ui**(enum *type*, uint *normal*)
void **NormalP3uiv**(enum *type*, uint **normal*)
void **FogCoord{fd}**(T *coord*);
void **FogCoord{fd}v**(T *coord*);
void **Color{34}{bsifd ubusui}**(T *components*);
void **Color{34}{bsifd ubusui}v**(T *components*);
void **ColorP{34}ui**(enum *type*, uint *coords*)
void **ColorP{34}uiv**(enum *type*, uint **coords*)
void **SecondaryColor3{bsifd ubusui}**(T *components*);
void **SecondaryColor3{bsifd ubusui}v**(T *components*);
void **SecondaryColorP3ui**(enum *type*, uint *coords*)
void SecondaryColorP3uiv(enum *type*, uint **coords*)
void **Index{sifd ub}**(T *index*);
void **Index{sifd ub}v**(T *index*);
void **VertexAttrib{1234}{sfd}**(uint *index*, T *values*);
void **VertexAttrib{123}{sfd}v**(uint *index*, T *values*);
void **VertexAttrib4{bsifd ub us ui}v**(uint *index*, T *values*);
void **VertexAttrib4Nub**(uint *index*, T *values*);
void **VertexAttrib4N{bsi ub us ui}v**(uint *index*, T *values*);
void **VertexAttribI{1234}{i ui}**(uint *index*, T *values*);
void **VertexAttribI{1234}{i ui}v**(uint *index*, T *values*);
void **VertexAttribI4{bs ub us}v**(uint *index*, T *values*);void **VertexAttribP{1234}ui**(uint *index*, enum *type*, boolean *normalized*, uint *value*)
void **VertexAttribP{1234}uiv**(uint *index*, enum *type*, boolean *normalized*, uint **value*)
type: *see VertexP{234}uiv*

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Rectangles, Matrices, Texture Coordinates

Rectangles [2.11]

Specifiy rectangles as two corner vertices.

void **Rect{sifd}**(T *x1*, T *y1*, T *x2*, T *y2*);

void **Rect{sifd}v**(T *v1*[2], T *v2*[2]);

Matrices [2.12.1]

void **MatrixMode**(enum *mode*);
mode: TEXTURE, MODELVIEW, COLOR, PROJECTION

void **LoadMatrix{fd}**(T *m*[16]);

void **MultMatrix{fd}**(T *m*[16]);

void **LoadTransposeMatrix{fd}**(T *m*[16]);

void **MultTransposeMatrix{fd}**(T *m*[16]);

void **LoadIdentity**(void);

void **Rotate{fd}**(T *θ*, T *x*, T *y*, T *z*);

void **Translate{fd}**(T *x*, T *y*, T *z*);

void **Scale{fd}**(T *x*, T *y*, T *z*);

void **Frustum**(double *l*, double *r*, double *b*, double *t*, double *n*, double *f*);

void **Ortho**(double *l*, double *r*, double *b*, double *t*, double *n*, double *f*);

void **PushMatrix**(void);

void **PopMatrix**(void);

Generating Texture Coords. [2.12.3]

void **TexGen{ifd}**(enum *coord*, enum *pname*, T *param*);

void **TexGen{ifd}v**(enum *coord*, enum *pname*, T *params);
coord: S, T, R, Q
pname: TEXTURE_GEN_MODE, OBJECT_PLANE, EYE_PLANE

Viewport and Clipping

Controlling the Viewport [2.17]

void **DepthRange**(clampd *n*, clampd *f*);

void **Viewport**(int *x*, int *y*, sizei *w*, sizei *h*);

Clipping [2.23, 6.1.3]

Enable/Disable(CLIP_DISTANCE*i*)
i: [0, MAX_CLIP_DISTANCES - 1]

void **ClipPlane**(enum *p*, double *eqn*[4]);
p: CLIP_PLANE*i* (where *i* is [0, MAX_CLIP_PLANES - 1])

void **GetClipPlane**(enum *plane*, double *eqn*[4]);

Lighting and Color

Enable/Disable(LIGHTING) // generic enable

Enable/Disable(LIGHT*i*) // indiv. lights

Lighting Parameter Spec. [2.13.2]

void **Material{if}**(enum *face*, enum *pname*, T *param*);

void **Material{if}v**(enum *face*, enum *pname*, T *params*);
face: FRONT, BACK, FRONT_AND_BACK
pname: AMBIENT, DIFFUSE, SPECULAR, AMBIENT_AND_DIFFUSE, EMISSION, SHININESS, COLOR_INDEXES

void **Light{if}**(enum *light*, enum *pname*, T *param*);

void **Light{if}v**(enum *light*, enum *pname*, T *params*);
light: LIGHT*i* (where *i* >= 0)
pname: AMBIENT, DIFFUSE, SPECULAR, POSITION, SPOT_{DIRECTION, EXPONENT, CUTOFF}, {CONSTANT, LINEAR,QUADRATIC}_ATTENUATION

void **LightModel{if}**(enum *pname*, T *param*);

void **LightModel{if}v**(enum *pname*, T *params*);
pname: LIGHT_MODEL_{AMBIENT, LOCAL_VIEWER}, LIGHT_MODEL_{TWO_SIDE, COLOR_CONTROL}

ColorMaterial [4.3.1] [2.13.3, 3.7.5]

Enable/Disable(COLOR_MATERIAL)

void **ColorMaterial**(enum *face*, enum *mode*);
face: FRONT, BACK, FRONT_AND_BACK
mode: EMISSION, AMBIENT, DIFFUSE, SPECULAR, AMBIENT_AND_DIFFUSE

void **ClampColor**(enum *target*, enum *clamp*);
target: CLAMP_VERTEX_COLOR
clamp: TRUE, FALSE, FIXED_ONLY

Flatshading [2.19] [2.22]

void **ProvokingVertex**(enum *provokeMode*);
provokeMode: {FIRST, LAST}_VERTEX_CONVENTION

void **ShadeModel**(enum *mode*);
mode: SMOOTH, FLAT

Queries [6.1.3]

void **GetLight{if}v**(enum *light*, enum *value*, T *data*);

void **GetMaterial{if}v**(enum *face*, enum *value*, T *data*);
face: FRONT, BACK

Rendering Control & Queries

Asynchronous Queries [2.15] [2.18]

void **BeginQuery**(enum *target*, uint *id*);
target: PRIMITIVES_GENERATED{*n*}, {ANY_}SAMPLES_PASSED, TIME_ELAPSED, TRANSFORM_FEEDBACK_PRIMITIVES_WRITTEN{*n*}

void **EndQuery**(enum *target*);

void **BeginQueryIndexed**(enum *target*, uint *index*, uint *id*);

void **EndQueryIndexed**(enum *target*, uint *index*);

void **GenQueries**(sizei *n*, uint *ids);

void **DeleteQueries**(sizei *n*, const uint *ids);

Conditional Rendering [2.16] [2.19]

void **BeginConditionalRender**(uint *id*, enum *mode*);

void **EndConditionalRender**(void);
mode: QUERY_WAIT, QUERY_NO_WAIT, QUERY_BY_REGION_{WAIT, NO_WAIT}

Transform Feedback [2.17] [2.20]

void **GenTransformFeedbacks**(sizei *n*, uint *ids);

void **DeleteTransformFeedbacks**(sizei *n*, const uint *ids);

void **BindTransformFeedback**(enum *target*, uint *id*);
target: TRANSFORM_FEEDBACK

void **BeginTransformFeedback**(enum *primitiveMode*);
primitiveMode: TRIANGLES, LINES, POINTS

void **EndTransformFeedback**(void);void PauseTransformFeedback(void);

void **ResumeTransformFeedback**(void);

void **DrawTransformFeedback**(enum *mode*, uint *id*);

void **DrawTransformFeedbackStream**(enum *mode*, uint *id*, uint *stream*);

Transform Feedback Query [6.1.11] [6.1.17]

boolean **IsTransformFeedback**(uint *id*);

Current Raster Position [2.25]

void **RasterPos{234}{sifd}**(T *coords*);

void **RasterPos{234}{sifd}v**(T *coords*);

void **WindowPos{23}{sifd}**(T *coords*);

void **WindowPos{23}{sifd}v**(T *coords*);

Asynch. State Queries [6.1.7] [6.1.13]

boolean **IsQuery**(uint *id*);

void **GetQueryiv**(enum *target*, enum *pname*, int *params);
target: *see BeginQuery*, plus TIMESTAMP
pname: CURRENT_QUERY, QUERY_COUNTER_BITS

void **GetQueryIndexediv**(enum *target*, uint *index*, enum *pname*, int *params);
target: *see BeginQuery*
pname: CURRENT_QUERY, QUERY_COUNTER_BITS

void **GetQueryObjectiv**(uint *id*, enum *pname*, int *params);

void **GetQueryObjectuiv**(uint *id*, enum *pname*, uint *params);

void **GetQueryObjecti64v**(uint *id*, enum *pname*, int64 *params);

void **GetQueryObjectui64v**(uint *id*, enum *pname*, uint64 *params);
pname: QUERY_RESULT{_AVAILABLE}

Shaders and Programs

Shader Objects [2.11.1] [2.14.1]

uint **CreateShader**(enum *type*);
type: {VERTEX, FRAGMENT, GEOMETRY}_SHADER, TESS_{EVALUATION, CONTROL}_SHADER

void **ShaderSource**(uint *shader*, sizei *count*, const char **string*, const int *length*);

void **CompileShader**(uint *shader*);

void **DeleteShader**(uint *shader*);

Program Objects [2.11.2] [2.14.2]

uint **CreateProgram**(void);

void **AttachShader**(uint *program*, uint *shader*);

void **DetachShader**(uint *program*, uint *shader*);

void **LinkProgram**(uint *program*);

void **UseProgram**(uint *program*);

void **DeleteProgram**(uint *program*);

Vertex Attributes [2.11.3] [2.14.3]

Vertex shaders operate on array of 4-comp. items numbered from slot 0 to MAX_VERTEX_ATTRIBS - 1.

void **GetActiveAttrib**(uint *program*, uint *index*, sizei *bufSize*, sizei *length*, int *size, enum *type, char *name);
*type returns: FLOAT, FLOAT_{VEC*n*, MAT*n*, MAT*nxm*}, INT, INT_VEC*n*, UNSIGNED_{INT, INT_VEC*n*}

int **GetAttribLocation**(uint *program*, const char *name);

void **BindAttribLocation**(uint *program*, uint *index*, const char *name);

Uniform Variables [2.11.4] [2.14.4]

int **GetUniformLocation**(uint *program*, const char *name);

uint **GetUniformBlockIndex**(uint *program*, const char *uniformBlockName);

void **GetActiveUniformBlockName**(uint *program*, uint *uniformBlockIndex*, sizei *bufSize*, sizei *length, char *uniformBlockName);

void **GetActiveUniformBlockiv**(uint *program*, uint *uniformBlockIndex*, enum *pname*, int *params);
pname: UNIFORM_BLOCK_{BINDING, DATA_SIZE}, UNIFORM_BLOCK_NAME_{LENGTH, UNIFORM}, UNIFORM_BLOCK_ACTIVE_UNIFORMS_INDICES, UNIFORM_BLOCK_REFERENCED_BY_{VERTEX_SHADER, FRAGMENT_SHADER, GEOMETRY_SHADER, TESS_CONTROL_SHADER, TESS_EVALUATION_SHADER}

void **GetUniformIndices**(uint *program*, sizei *uniformCount*, const char **uniformNames*, uint *uniformIndices);

void **GetActiveUniformName**(uint *program*, uint *uniformIndex*, sizei *bufSize*, sizei *length*, char *uniformName);

void **GetActiveUniform**(uint *program*, uint *index*, sizei *bufSize*, sizei *length*, int *size, enum *type, char *name);
*type returns: DOUBLE, DOUBLE_{VEC*n*, MAT*n*, MAT*nxn*}, FLOAT, FLOAT_{VEC*n*, MAT*n*, MAT*nxn*}, INT, INT_VEC*n*, UNSIGNED_INT, UNSIGNED_INT_VEC*n*, BOOL, BOOL_VEC*n*, and the SAMPLER_*, INT_SAMPLER_*, and UNSIGNED_INT_SAMPLER_* values in [Table 2.12] [Table 2.15]

void **GetActiveUniformsiv**(uint *program*, sizei *uniformCount*, const uint *uniformIndices, enum *pname*, int *params);
pname: UNIFORM_{TYPE, SIZE, NAME_LENGTH}, UNIFORM_BLOCK_INDEX, UNIFORM_OFFSET, UNIFORM_{ARRAY, MATRIX}_STRIDE, UNIFORM_IS_ROW_MAJOR

Load Uniform Variables In Default Uniform Block

void **Uniform{1234}{ifd}**(int *location*, T *value*);

void **Uniform{1234}{ifd}v**(int *location*, sizei *count*, T *value*);

void **Uniform{1234}ui**(int *location*, T *value*);

void **Uniform{1234}uiv**(int *location*, sizei *count*, T *value*);

void **UniformMatrix{234}{fd}v**(int *location*, sizei *count*, boolean *transpose*, const T *value*);

void **UniformMatrix{2x3,3x2,2x4,4x2, 3x4,4x3}{fd}v**(int *location*, sizei *count*, boolean *transpose*, const T *value*);

(parameters 1)

Uniform Buffer Object Bindings

void **UniformBlockBinding**(uint *program*, uint *uniformBlockIndex*, uint *uniformBlockBinding*);

Subroutine Uniform Variables [2.11.5] [2.14.5]

int **GetSubroutineUniformLocation**(uint *program*, enum *shadertype*, const char *name);

uint **GetSubroutineIndex**(uint *program*, enum *shadertype*, const char *name);

void **GetActiveSubroutineUniformiv**(uint *program*, enum *shadertype*, uint *index*, enum *pname*, int *values);
pname: {NUM_}COMPATIBLE_SUBROUTINES, UNIFORM_SIZE, UNIFORM_NAME_LENGTH

void **GetActiveSubroutineUniformName**(uint *program*, enum *shadertype*, uint *index*, sizei *bufsize*, sizei *length*, char *name);

void **GetActiveSubroutineName**(uint *program*, enum *shadertype*, uint *index*, sizei *bufsize*, sizei *length*, char *name);

void **UniformSubroutinesuiv**(enum *shadertype*, sizei *count*, const uint *indices);

Varying Variables [2.11.7] [2.14.7]

void **TransformFeedbackVaryings**(uint *program*, sizei *count*, const char **varyings*, enum *bufferMode*);
bufferMode: {INTERLEAVED, SEPARATE}_ATTRIBS

void **GetTransformFeedbackVarying**(uint *program*, uint *index*, sizei *bufSize*, sizei *length*, sizei *size, enum *type, char *name);
*type returns NONE, FLOAT, FLOAT_VEC*n*, DOUBLE, DOUBLE_VEC*n*, {UNSIGNED_}INT, INT_VEC*n*, UNSIGNED_INT_VEC*n*, FLOAT_MAT*n*, MAT*nxm*, DOUBLE_MAT*n*, {FLOAT, DOUBLE}_MAT*nxm*.

Shader Execution [2.11.8] [2.14.8]

void **ValidateProgram**(uint *program*);

Tessellation Control Shaders [2.12.1] [2.15.1]

void **PatchParameterfv**(enum *pname*, const float *values);
pname: PATCH_DEFAULT_{INNER, OUTER}_LEVEL

Fragment Shaders [3.9.2] [3.12.2]

void **BindFragDataLocation**(uint *program*, uint *colorNumber*, const char *name);

void **BindFragDataLocationIndexed**(uint *program*, uint *colorNumber*, uint *index*, const char *name);

int **GetFragDataLocation**(uint *program*, const char *name);

int **GetFragDataIndex**(uint *program*, const char *name);

Shader Queries

Shader Queries [6.1.12] [6.1.18]

boolean **IsShader**(uint *shader*);

void **GetShaderiv**(uint *shader*, enum *pname*, int *params);
pname: SHADER_TYPE, {DELETE,COMPILE}_STATUS, INFO_LOG_LENGTH, SHADER_SOURCE_LENGTH

void **GetShaderInfoLog**(uint *shader*, sizei *bufSize*, sizei *length*, char *infoLog);

void **GetShaderSource**(uint *shader*, sizei *bufSize*, sizei *length*, char *source);

void **GetProgramStageiv**(uint program, enum *shadertype*, enum *pname*, int *values);
pname: ACTIVE_SUBROUTINE_{UNIFORMS, MAX_LENGTH}, ACTIVE_SUBROUTINES, ACTIVE_SUBROUTINE_UNIFORM_{LOCATIONS, MAX_LENGTH}

Program Queries [6.1.12] [6.1.18]

void **GetAttachedShaders**(uint *program*, sizei *maxCount*, sizei *count*, uint *shaders);

void **GetVertexAttrib{d f i}v**(uint *index*, enum *pname*, T *params);
pname: VERTEX_ATTRIB_ARRAY_{BUFFER_BINDING, ENABLED, SIZE, STRIDE, TYPE, NORMALIZED, DIVISOR , INTEGER}, CURRENT_VERTEX_ATTRIB

void **GetVertexAttribI{i ui}v**(uint *index*, enum *pname*, T *params);
pname: *see GetVertexAttrib{d f i}v*

void **GetVertexAttribPointerv**(uint *index*, enum *pname*, void **pointer*);
pname: VERTEX_ATTRIB_ARRAY_POINTER

void **GetUniform{f d i ui}v**(uint *program*, int *location*, T *params)

void **GetUniformSubroutineuiv**(enum *shadertype*, int *location*, uint *params);

boolean **IsProgram**(uint *program*);

void **GetProgramiv**(uint *program*, enum *pname*, int *params);
pname: {DELETE, *LINK, VALIDATE*}_STATUS, INFO_LOG_LENGTH, ATTACHED_SHADERS, ACTIVE_{ATTRIBUTES, *UNIFORMS*}, ACTIVE_{ATTRIBUTES, *UNIFORM*}_MAX_LENGTH, TRANSFORM_FEEDBACK_{BUFFER_MODE, *VARYINGS*}, ACTIVE_UNIFORM_BLOCKS, TRANSFORM_FEEDBACK_VARYING_MAX_LENGTH, ACTIVE_UNIFORM_BLOCK_MAX_NAME_LENGTH, GEOMETRY_VERTICES_OUT, GEOMETRY_{INPUT, *OUTPUT*}_TYPE, GEOMETRY_SHADER_INVOCATIONS, TESS_CONTROL_OUTPUT_VERTICES, TESS_GEN_{MODE, *SPACING*}, TESS_GEN_{VERTEX_ORDER, *POINT_MODE*}

void **GetProgramInfoLog**(uint *program*, sizei *bufSize*, sizei *length*, char *infoLog);

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Rasterization [3]

Enable/Disable(*target*)
target: RASTERIZER_DISCARD, MULTISAMPLE, SAMPLE_SHADING

Multisampling [3.3.1]

Use to antialias points, lines, polygons, bitmaps, and images.

void **GetMultisamplefv**(enum *pname*, uint *index*, float *val);
pname: SAMPLE_POSITION

void **MinSampleShading**(clampf *value*);

Points [3.4]

void **PointSize**(float *size*);
void **PointParameter{if}**(enum *pname*, T *param*);
void **PointParameter{if}v**(enum *pname*, const T *params*);
pname: POINT_SIZE_MIN, POINT_SIZE_MAX, POINT_DISTANCE_ATTENUATION, POINT_FADE_THRESHOLD_SIZE, POINT_SPRITE_COORD_ORIGIN
param, params: LOWER_LEFT, UPPER_LEFT, pointer to point fade threshold

Enable/Disable (*target*)
target: VERTEX_PROGRAM_POINT_SIZE, POINT_SMOOTH, POINT_SPRITE.

Line Segments [3.5]

void **LineWidth**(float *width*);
Enable/Disable(LINE_SMOOTH)

Other Line Seg. Features [3.5.2, 6.1.6]

void **LineStipple**(int *factor*, ushort *pattern*);
Enable/Disable(LINE_STIPPLE)
void **GetIntegerv**(LINE_STIPPLE_PATTERN);

Polygons [3.6]

Enable/Disable(*target*)
target: POLYGON_STIPPLE, POLYGON_SMOOTH, CULL_FACE

void **FrontFace**(enum *dir*);
dir: CCW, CW

void **CullFace**(enum *mode*);
mode: FRONT, BACK, FRONT_AND_BACK

Stippling [3.6.2]

void **PolygonStipple**(ubyte *pattern);
void **GetPolygonStipple**(void *pattern);

Polygon Rasterization & Depth Offset [3.6.3 - 3.6.4] [3.6.4 - 3.6.5]

void **PolygonMode**(enum *face*, enum *mode*);
face: FRONT, BACK, FRONT_AND_BACK
mode: POINT, LINE, FILL

void **PolygonOffset**(float *factor*, float *units*);
Enable/Disable(*target*)
target: POLYGON_OFFSET_POINT, POLYGON_OFFSET_{LINE, FILL}

Pixel Storage Modes & Buffer Objects [3.7.1]

void **PixelStore{if}**(enum *pname*, T *param*);
pname: {UN}PACK_*x* (where *x* may be SWAP_BYTES, LSB_FIRST, ROW_LENGTH, SKIP_{PIXELS, ROWS}, ALIGNMENT, IMAGE_HEIGHT, SKIP_IMAGES)

Pixel Transfer Modes [3.7.3, 6.1.3]

void **PixelTransfer{if}**(enum *param*, T *value*);
param: MAP_{COLOR, STENCIL}, INDEX_{SHIFT, OFFSET}, *x*_{SCALE, BIAS}, DEPTH_{SCALE, BIAS}, POST_CONVOLUTION_*x*_{SCALE, BIAS}, POST_COLOR_MATRIX_*x*_{SCALE, BIAS}, (where *x* is RED, GREEN, BLUE, or ALPHA) [Table 3.2]

void **PixelMap{ui us f}v**(enum *map*, sizei *size*, T *values*);
map: PIXEL_MAP_*x*_TO_*x (where x may be {I,S,R,G,B,A}), PIXEL_MAP_I_TO_{R,G,B,A}* [Table 3.3]

void **GetPixelMap{ui us f}v**(enum *map*, T *data*);
map: *see PixelMap{ui us f}v*

Color Table Specification [3.7.3]

void **ColorTable**(enum *target*, enum *internalformat*, sizei *width*, enum *format*, enum *type*, void *data);
target: {PROXY_}COLOR_TABLE, {PROXY_}POST_CONVOLUTION_COLOR_TABLE, {PROXY_}POST_COLOR_MATRIX_COLOR_TABLE
internalformat: The formats in [Table 3.16] or [Tables 3.17-3.19] except RED, RG, DEPTH_{COMPONENT, STENCIL} base and sized internal formats in those tables, all sized internal formats with non-fixed internal data types as discussed in [3.9], and RGB9_E5.
format: RED, GREEN, BLUE, ALPHA, RG, RGB, RGBA, BGRA, LUMINANCE, LUMINANCE_ALPHA
type: *see DrawPixels*

Enable/Disable(POST_COLOR_MATRIX_COLOR_TABLE)

void **ColorTableParameter{if}v**(enum *target*, enum *pname*, T *params*);
target: POST_COLOR_MATRIX_COLOR_TABLE, {POST_CONVOLUTION_}COLOR_TABLE
pname: COLOR_TABLE_SCALE, COLOR_TABLE_BIAS

Alt. Color Table Specification Commands

void **CopyColorTable**(enum *target*, enum *internalformat*, int *x*, int *y*, sizei *width*);

void **ColorSubTable**(enum *target*, sizei *start*, sizei *count*, enum *format*, enum *type*, void *data);

void **CopyColorSubTable**(enum *target*, sizei *start*, int *x*, int *y*, sizei *count*);
target and pname: *see ColorTableParameter{if}v*

Color Table Query [6.1.8]

void **GetColorTable**(enum *target*, enum *format*, enum *type*, void *table);
target: *see ColorTableParameter{if}v*
format and type: *see GetTexImage*, omitting DEPTH_COMPONENT for *format*

void **GetColorTableParameter{if}v**(enum *target*, enum *pname*, T *params*);
target: *see ColorTable*
pname: COLOR_TABLE_*x* (where *x* may be SCALE, BIAS, FORMAT, COLOR_TABLE_WIDTH, RED_SIZE, GREEN_SIZE, BLUE_SIZE, ALPHA_SIZE, LUMINANCE_SIZE, INTENSITY_SIZE)

Convolution Filter Specification [3.7.3]

Enable/Disable(POST_CONVOLUTION_COLOR_TABLE)

void **ConvolutionFilter2D**(enum *target*, enum *internalformat*, sizei *width*, sizei *height*, enum *format*, enum *type*, void *data);
target: CONVOLUTION_2D
internalformat: *see ColorTable*
format: RED, GREEN, BLUE, ALPHA, RG, RGB, RGBA, BGRA, LUMINANCE, LUMINANCE_ALPHA
type: BYTE, SHORT, INT, FLOAT, HALF_FLOAT, UNSIGNED_{BYTE, SHORT, INT}

void **ConvolutionFilter1D**(enum *target*, enum *internalformat*, sizei *width*, enum *format*, enum *type*, void *data);
target: CONVOLUTION_1D
internalformat, format, type: *see ConvolutionFilter2D*

void **ConvolutionParameter{if}v**(enum *target*, enum *pname*, T *params*);
target: CONVOLUTION_2D
pname: CONVOLUTION_FILTER_{SCALE, BIAS}

void **SeparableFilter2D**(enum *target*, enum *internalformat*, sizei *width*, sizei *height*, enum *format*, enum *type*, void *row*, void *column*);
target: SEPARABLE_2D
internalformat, format, type: *see ConvolutionFilter2D*

Alt. Convolution Filter Spec. Commands

void **CopyConvolutionFilter2D**(enum *target*, enum *internalformat*, int *x*, int *y*, sizei *width*, sizei *height*);
target: CONVOLUTION_2D
internalformat: *see ConvolutionFilter2D*

void **CopyConvolutionFilter1D**(enum *target*, enum *internalformat*, int *x*, int *y*, sizei *width*);
target: CONVOLUTION_1D
internalformat: *see ConvolutionFilter2D*

Convolution Query [6.1.9]

void **GetConvolutionFilter**(enum *target*, enum *format*, enum *type*, void *image);
target: CONVOLUTION_1D, CONVOLUTION_2D
format and *type:* *see GetTexImage*, omitting DEPTH_COMPONENT in *format*

void **GetSeparableFilter**(enum *target*, enum *format*, enum *type*, void *row*, void *column*, void *span*);
target: SEPARABLE_2D
format and *type:* *see GetTexImage*

void **GetConvolutionParameter{if}v**(enum *target*, enum *pname*, T *params*);
target: CONVOLUTION_1D, CONVOLUTION_2D, SEPARABLE_2D
pname: {MAX_}CONVOLUTION_{WIDTH, HEIGHT}, CONVOLUTION_*x* (where *x* may be FILTER_BIAS, BORDER_COLOR, BORDER_MODE, FILTER_SCALE, FORMAT)

Histogram Table Specification [3.7.3]

void **Histogram**(enum *target*, sizei *width*, enum *internalformat*, boolean *sink*);
target: HISTOGRAM, PROXY_HISTOGRAM
internalformat: *see ColorTable* except 1, 2, 3, and 4

Histogram Query [6.1.10]

void **GetHistogram**(enum *target*, boolean *reset*, enum *format*, enum *type*, void *values*);
target: HISTOGRAM
format and *type:* *see GetTexImage*, omitting DEPTH_COMPONENT for *format*

void **ResetHistogram**(enum *target*);
target: HISTOGRAM

void **GetHistogramParameter{if}v**(enum *target*, enum *pname*, T *params*);
target: HISTOGRAM, PROXY_HISTOGRAM
pname: HISTOGRAM_*x* (where *x* may be FORMAT, WIDTH, {RED, GREEN, BLUE, ALPHA}_SIZE, LUMINANCE_SIZE, SINK)

Minmax Table Specification [3.7.3]

Enable/Disable(MINMAX)
void **Minmax**(enum *target*, enum *internalformat*, boolean *sink*);
target: MINMAX
internalformat: *see ColorTable*, omitting the values 1, 2, 3, 4 and INTENSITY base and sized internal formats

Minmax Query [6.1.11]

void **GetMinmax**(enum *target*, boolean *reset*, enum *format*, enum *type*, void *values*);
target: MINMAX
format and *type:* *see GetTexImage*, omitting DEPTH_COMPONENT for *format*

void **ResetMinmax**(enum *target*);
target: MINMAX

void **GetMinmaxParameter{if}v**(enum *target*, enum *pname*, T *params*);
target: MINMAX
pname: MINMAX_FORMAT, MINMAX_SINK

Rasterization of Pixel Rectangles [4.3.1] [3.7.5]

void **DrawPixels**(sizei *width*, sizei *height*, enum *format*, enum *type*, void *data);
format: {COLOR|STENCIL}_INDEX, DEPTH_{COMPONENT, STENCIL}, RED, GREEN, BLUE, ALPHA, RG, RGB, RGBA, BGR, BGRA, LUMINANCE{_ALPHA} (*_INTEGER formats from {Table 3.6} are not supported)
type: BITMAP, BYTE, SHORT, INT, FLOAT, HALF_FLOAT, UNSIGNED_{BYTE, SHORT, INT}, or value from [Table 3.5]

void **ClampColor**(enum *target*, enum *clamp*);
target: CLAMP_READ_COLOR, CLAMP_{FRAGMENT, VERTEX}_COLOR
clamp: TRUE, FALSE, FIXED_ONLY

void **PixelZoom**(float *zx*, float *zy*);

Pixel Transfer Operations [3.7.6]

void **ConvolutionParameter{if}**(enum *target*, enum *pname*, T *param*);
target: CONVOLUTION_1D, CONVOLUTION_2D, SEPARABLE_2D
pname: CONVOLUTION_BORDER_MODE
param: REDUCE, {CONSTANT, REPLICATE_}BORDER

Bitmaps [3.8]

void **Bitmap**(sizei *w*, sizei *h*, float *xb0*, float *yb0*, float *xbi*, float *ybi*, ubyte *data);

Texturing [3.8] [3.9]

void **ActiveTexture**(enum *texture*);
texture: TEXTURE*i* (where *i* is [0, MAX(MAX_TEXTURE_COORDS, MAX_COMBINED_TEXTURE_IMAGE_UNITS)-1])

Texture Objects [3.8.1] [3.9.1]

void **BindTexture**(enum *target*, uint *texture*);
target: TEXTURE_{1, 2}D{_ARRAY}, TEXTURE_{3D, RECTANGLE, BUFFER}, TEXTURE_CUBE_MAP{_ARRAY}, TEXTURE_2D_MULTISAMPLE{_ARRAY}

void **DeleteTextures**(sizei *n*, uint *textures);

void **GenTextures**(sizei *n*, uint *textures);

boolean **AreTexturesResident**(sizei *n*, uint *textures, boolean *residences);

void **PrioritizeTextures**(sizei *n*, uint *textures, clampf *priorities);

Sampler Objects [3.8.2] [3.9.2]

void **GenSamplers**(sizei *count*, uint *samplers);

void **BindSampler**(uint *unit*, uint *sampler*);

void **SamplerParameter{if}v**(uint *sampler*, enum *pname*, T *param*);

void **SamplerParameterI{u ui}v**(uint *sampler*, enum *pname*, T *params);
pname: TEXTURE_WRAP_{S, T, R}, TEXTURE_{MIN, MAG}_FILTER, TEXTURE_{MIN,MAX}_LOD, TEXTURE_BORDER_COLOR, TEXTURE_LOD_BIAS, TEXTURE_COMPARE_{MODE, FUNC}

(more parameters ↴)

void **DeleteSamplers**(sizei *count*, const uint *samplers);

Texture Image Spec. [3.8.3] [3.9.3]

void **TexImage3D**(enum *target*, int *level*, int *internalformat*, sizei *width*, sizei *height*, sizei *depth*, int *border*, enum *format*, enum *type*, void *data);
target: {PROXY_}TEXTURE_3D, {PROXY_}TEXTURE_2D_ARRAY, {PROXY_}TEXTURE_CUBE_MAP_ARRAY
internalformat: ALPHA, DEPTH_COMPONENT, DEPTH_STENCIL, LUMINANCE{_ALPHA}, RED, INTENSITY, RG, RGB, RGBA; or a sized internal format from [Tables 3.12-3.13] [Tables 3.17-3.19]; COMPRESSED_{SIGNED_}{RED_RGTC1,RG_RGTC2}, or a generic comp. format in [Table 3.14] [Table 3.20]
format: COLOR_INDEX, DEPTH_{COMPONENT, STENCIL}, RED, GREEN, BLUE, ALPHA, RG, RGB, RGBA, BGR, BGRA, LUMINANCE{_ALPHA}, {RED, GREEN, BLUE, ALPHA}_INTEGER, RG_INTEGER, RGB_INTEGER, RGBA_INTEGER, BGR_INTEGER, BGRA_INTEGER [Table 3.3] [Table 3.6]
type: BITMAP, BYTE, UNSIGNED_BYTE, SHORT, UNSIGNED_SHORT, INT, UNSIGNED_INT, HALF_FLOAT, FLOAT, or a value from [Table 3.2] [Table 3.5]

void **TexImage2D**(enum *target*, int *level*, int *internalformat*, sizei *width*, sizei *height*, int *border*, enum *format*, enum *type*, void *data);
target: {PROXY_}TEXTURE_{2D, RECTANGLE,CUBE_MAP}, {PROXY_}TEXTURE_1D_ARRAY, TEXTURE_CUBE_MAP_{POSITIVE, NEGATIVE}_{X, Y, Z},
internalformat, format, and *type:* *see TexImage3D*

void **TexImage1D**(enum *target*, int *level*, int *internalformat*, sizei *width*, int *border*, enum *format*, enum *type*, void *data);
target: TEXTURE_1D, PROXY_TEXTURE_1D
type, internalformat, and *format:* *see TexImage3D*

Alt. Tex. Image Specification [3.8.4] [3.9.4]

void **CopyTexImage2D**(enum *target*, int *level*, enum *internalformat*, int *x*, int *y*, sizei *width*, sizei *height*, int *border*);
target: TEXTURE_{2D, RECTANGLE}, TEXTURE_1D_ARRAY, TEXTURE_CUBE_MAP_{POSITIVE, NEGATIVE}_{X, Y, Z}
internalformat: *see TexImage2D*, except 1, 2, 3, 4

void **CopyTexImage1D**(enum *target*, int *level*, enum *internalformat*, int *x*, int *y*, sizei *width*, int *border*);
target: TEXTURE_1D
internalformat: *see TexImage1D*, except 1, 2, 3, 4

void **TexSubImage3D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *zoffset*, sizei *width*, sizei *height*, sizei *depth*, enum *format*, enum *type*, void *data);

(parameters ↴)

target: TEXTURE_3D, TEXTURE_2D_ARRAY, TEXTURE_CUBE_MAP_ARRAY
format and *type:* *see TexImage3D*

void **TexSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, sizei *width*, sizei *height*, enum *format*, enum *type*, void *data);
target: *see CopyTexImage2D*
format and *type:* *see TexImage2D*

void **TexSubImage1D**(enum *target*, int *level*, int *xoffset*, sizei *width*, enum *format*, enum *type*, void *data);
target: TEXTURE_1D
format, type: *see TexImage1D*

void **CopyTexSubImage3D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *zoffset*, int *x*, int *y*, sizei *width*, sizei *height*);
target: *see TexSubImage3D*

void **CopyTexSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *x*, int *y*, sizei *width*, sizei *height*);
target: TEXTURE_2D, TEXTURE_1D_ARRAY, TEXTURE_RECTANGLE, TEXTURE_CUBE_MAP_{POSITIVE, NEGATIVE}_{X, Y, Z}

void **CopyTexSubImage1D**(enum *target*, int *level*, int *xoffset*, int *x*, int *y*, sizei *width*);
target: TEXTURE_1D

(Continued >)

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Texturing (continued)

Compressed Texture Images [3.8.5] [3.9.5]

void **CompressedTexImage3D**(enum *target*, int *level*, enum *internalformat*, sizei *width*, sizei *height*, sizei *depth*, int *border*, sizei *imageSize*, void **data*);
target: see TexImage3D
internalformat: COMPRESSED_RED_RGTC1_RED, COMPRESSED_SIGNED_RED_RGTC1_RED, COMPRESSED_RG_RGTC2_RG, COMPRESSED_SIGNED_RG_RGTC2

void **CompressedTexImage2D**(enum *target*, int *level*, enum *internalformat*, sizei *width*, sizei *height*, int *border*, sizei *imageSize*, void **data*);
target: see TexImage2D, omitting compressed rectangular texture formats
internalformat: see CompressedTexImage3D

void **CompressedTexImage1D**(enum *target*, int *level*, enum *internalformat*, sizei *width*, int *border*, sizei *imageSize*, void **data*);
target: TEXTURE_1D, PROXY_TEXTURE_1D
internalformat: values are implementation-dependent

void **CompressedTexSubImage3D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *zoffset*, sizei *width*, sizei *height*, sizei *depth*, enum *format*, sizei *imageSize*, void **data*);
target: see TexSubImage3D
format: see internalformat for CompressedTexImage3D

void **CompressedTexSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, sizei *width*, sizei *height*, enum *format*, sizei *imageSize*, void **data*);
target: see TexSubImage2D
format: see TexImage2D

void **CompressedTexSubImage1D**(enum *target*, int *level*, int *xoffset*, sizei *width*, enum *format*, sizei *imageSize*, void **data*);
target: see TexSubImage1D
format: see TexImage1D

Multisample Textures [3.8.6] [3.9.6]

void **TexImage3DMultisample**(enum *target*, sizei *samples*, int *internalformat*, sizei *width*, sizei *height*, sizei *depth*, boolean *fixedsamplelocations*);
target: {PROXY_}TEXTURE_2D_MULTISAMPLE_ARRAY
internalformat: ALPHA, RED, RG, RGB, RGBA, DEPTH_{COMPONENT, STENCIL}, STENCIL_INDEX, or sized internal formats corresponding to these base formats

void **TexImage2DMultisample**(enum *target*, sizei *samples*, int *internalformat*, sizei *width*, sizei *height*,boolean *fixedsamplelocations*);
target: {PROXY_}TEXTURE_2D_MULTISAMPLE
internalformat: see TexImage3DMultisample

Buffer Textures [3.8.7] [3.9.7]

void **TexBuffer**(enum *target*, enum *internalformat*, uint *buffer*);
target: TEXTURE_BUFFER
internalformat: R8{I,UI}, R16{F, I, UI}, R32{F, I, UI}, RG8{I, UI}, RG16{F, I, UI}, RG32{F, I, UI}, RGB32{F, I, UI}, RGBA8{I, UI}, RGBA16{F, I, UI}, RGBA32{F, I, UI}

Texture Parameters [3.8.8] [3.9.8]

void **TexParameter{if}**(enum *target*, enum *pname*, T *param*);
void **TexParameter{if}v**(enum *target*, enum *pname*, T **params*);
void **TexParameterI{i ui}v**(enum *target*, enum *pname*, T **params*);
target: TEXTURE_{1D,2D,3D}, TEXTURE_{1D,2D}_ARRAY, TEXTURE_RECTANGLE, TEXTURE_CUBE_MAP{_ARRAY}
pname: TEXTURE_WRAP_{S, T, R}, TEXTURE_PRIORITY, TEXTURE_{MIN, MAG}_FILTER, TEXTURE_LOD_BIAS, TEXTURE_BORDER_COLOR, DEPTH_TEXTURE_MODE, TEXTURE_{MIN, MAX}_LOD, GENERATE_MIPMAP, TEXTURE_SWIZZLE_{R, G, B, A, RGBA}, TEXTURE_{BASE, MAX}_LEVELS, TEXTURE_COMPARE_{MODE, FUNC} [Table 3.16] [Table 3.22]

Cube Map Texture Selection [3.8.10] [3.9.10]

Enable/Disable(TEXTURE_CUBE_MAP_SEAMLESS)

Texture Minification [3.8.11] [3.9.11]

void **GenerateMipmap**(enum *target*);
target: TEXTURE_{1D, 2D, 3D}, TEXTURE_{1D, 2D}_ARRAY, TEXTURE_CUBE_MAP{_ARRAY}.

Texture Environments & Functions [3.9.16]

void **TexEnv{if}**(enum *target*, enum *pname*, T *param*);
void **TexEnv{if}v**(enum *target*, enum *pname*, T *params*);
target: TEXTURE_{FILTER_CONTROL, ENV}, POINT_SPRITE
pname: TEXTURE_LOD_BIAS, TEXTURE_ENV_MODE, TEXTURE_ENV_COLOR, COMBINE_{RGB, ALPHA}, {RGB, ALPHA}_SCALE, COORD_REPLACE, SRC*n*_RGB, SRC*n*_ALPHA, OPERAND*n*_RGB, OPERAND*n*_ALPHA (where *n* is [0, 1, 2])

Texture Application [3.8.18] [3.9.20]

Enable/Disable(*param*)
param: TEXTURE_1D, TEXTURE_2D, TEXTURE_3D, TEXTURE_CUBE_MAP

Enumerated Queries [6.1.3]

void **GetTexEnv{if}v**(enum *env*, enum *value*, T *data*);
env: POINT_SPRITE, TEXTURE_{ENV,FILTER_CONTROL}
void **GetTexGen{ifd}v**(enum *coord*, enum *value*, T *data*);
coord: S, T, R, Q
void **GetTexParameter{if}v**(enum *target*, enum *value*, T *data*);
void **GetTexParameterI{i ui}v**(enum *target*, enum *value*, T *data*);
target: TEXTURE_{1D, 2D, 3D,RECTANGLE}, TEXTURE_{1D, 2D}_ARRAY, TEXTURE_CUBE_MAP{_ARRAY}
value: TEXTURE_{RESIDENT, PRIORITY}, DEPTH_TEXTURE_MODE, GENERATE_MIPMAP, TEXTURE_{BASE, MAX}_LEVEL, TEXTURE_BORDER_COLOR, TEXTURE_LOD_BIAS, TEXTURE_COMPARE_{MODE, FUNC}, TEXTURE_{MIN, MAG}_FILTER, TEXTURE_MAX_{LEVEL, LOD}, TEXTURE_MIN_LOD, TEXTURE_SWIZZLE_{R, G, B, A, RGBA}, TEXTURE_WRAP_{S, T, R} [Table 3.16, 3.22]
void **GetTexLevelParameter{if}v**(enum *target*, int *lod*, enum *value*, T *data*);
target: {PROXY_}TEXTURE_{1D, 2D, 3D}, TEXTURE_BUFFER, PROXY_TEXTURE_CUBE_MAP, {PROXY_}TEXTURE_{1D, 2D}_ARRAY, {PROXY_}TEXTURE_CUBE_MAP_ARRAY, {PROXY_}TEXTURE_RECTANGLE, TEXTURE_CUBE_MAP_{POSITIVE, *NEGATIVE*}_{X, Y, Z}, TEXTURE_2D_MULTISAMPLE{_ARRAY}, PROXY_TEXTURE_2D_MULTISAMPLE, PROXY_TEXTURE_2D_MULTISAMPLE{_ARRAY}
value: TEXTURE_{WIDTH, HEIGHT, DEPTH}, TEXTURE_{BORDER, COMPONENTS, SAMPLES}, TEXTURE_FIXED_SAMPLE_LOCATIONS, TEXTURE_{INTERNAL_FORMAT, SHARED_SIZE}, TEXTURE_COMPRESSED{_IMAGE_SIZE}, TEXTURE_BUFFER_DATA_STORE_BINDING, TEXTURE_x_{SIZE, TYPE} (where x can be RED, GREEN, BLUE, ALPHA, LUMINANCE, INTENSITY, DEPTH, STENCIL)

(parameters 1)

Texture Queries [6.1.4]

void **GetTexImage**(enum *tex*, int *lod*, enum *format*, enum *type*, void **img*);
tex: TEXTURE_{1, 2}D{_ARRAY}, TEXTURE_3D, TEXTURE_RECTANGLE, TEXTURE_CUBE_MAP_ARRAY, TEXTURE_CUBE_MAP_{POSITIVE,NEGATIVE}_{X, Y, Z}
format: see TexImage3D
type: BITMAP, {UNSIGNED_}BYTE, UNSIGNED_{SHORT}, {UNSIGNED_}INT, {HALF_}FLOAT, or a value from [Table 3.2] [Table 3.5]
void **GetCompressedTexImage**(enum *target*, int *lod*, void **img*);
target: see "tex" for GetTexImage
boolean **IsTexture**(uint *texture*);

Sampler Queries [6.1.5]

boolean **IsSampler**(uint *sampler*);
void **GetSamplerParameter{if}v**(uint *sampler*, enum *pname*, T **params*);
void **GetSamplerParameterI{i ui}v**(uint *sampler*, enum *pname*, T **params*);
pname: TEXTURE_WRAP_{S, T, R}, TEXTURE_{MIN, MAG}_FILTER, TEXTURE_BORDER_COLOR, TEXTURE_LOD_BIAS, TEXTURE_{MIN, MAX}_LOD, TEXTURE_COMPARE_{MODE, FUNC}

Color Sum, Fog, and Hints

Color Sum [3.10]

Enable/Disable(COLOR_SUM)

Fog [3.11]

Enable/Disable(FOG)
void **Fog{if}**(enum *pname*, T *param*);
void **Fog{if}v**(enum *pname*, T *params*);
pname: FOG_MODE, FOG_COORD_SRC, FOG_DENSITY, FOG_START, FOG_END, FOG_COLOR, FOG_INDEX

Hints [5.8]

void **Hint**(enum *target*, enum *hint*);
target: FRAGMENT_SHADER_DERIVATIVE_HINT, TEXTURE_COMPRESSION_HINT, PERSPECTIVE_CORRECTION_HINT, {LINE, POLYGON,POINT}_SMOOTH_HINT, FOG_HINT, GENERATE_MIPMAP_HINT
hint: FASTEST, NICEST, DONT_CARE

Drawing, Reading, and Copying Pixels

Reading Pixels [4.3.1] [4.3.2]

void **ReadPixels**(int *x*, int *y*, sizei *width*, sizei *height*, enum *format*, enum *type*, void **data*);
format: {COLOR, STENCIL}_INDEX, DEPTH_{COMPONENT, STENCIL}, RED, GREEN, BLUE, ALPHA, RG, RGB, RGBA, BGR, BGRA LUMINANCE{_ALPHA}, {RED, GREEN, BLUE, ALPHA, RG, RGB, RGBA, BGR, BGRA}_INTEGER [Table 3.3] [Table 3.6]
type: BITMAP, {HALF_}FLOAT, {UNSIGNED_}BYTE, {UNSIGNED_}SHORT, {UNSIGNED_}INT, FLOAT_32_UNSIGNED_INT_24_8_REV, and the UNSIGNED_{BYTE, SHORT, INT}_* values from [Table 3.2] [Table 3.5]

Also see DrawPixels, ClampColor, and PixelZoom in the Rasterization section of this reference card.

void **ReadBuffer**(enum *src*);
src: NONE, FRONT{_LEFT, RIGHT}, LEFT, RIGHT, BACK{_LEFT, RIGHT}, FRONT_AND_BACK, AUX*i* (where *i* is [0, AUX_BUFFERS - 1]), COLOR_ATTACHMENT*i* (where *i* is [0, MAX_COLOR_ATTACHMENTS - 1])

Copying Pixels [4.3.2] [4.3.3]

void **CopyPixels**(int *x*, int *y*, sizei *width*, sizei *height*, enum *type*);
type: COLOR, STENCIL, DEPTH, DEPTH_STENCIL
void **BlitFramebuffer**(int *srcX0*, int *srcY0*, int *srcX1*, int *srcY1*, int *dstX0*, int *dstY0*, int *dstX1*, int *dstY1*, bitfield *mask*, enum *filter*);
mask: Bitwise OR of {COLOR, DEPTH, STENCIL}_BUFFER_BIT
filter: LINEAR, NEAREST

Whole Framebuffer Operations

Selecting a Buffer for Writing [4.2.1]

void **DrawBuffer**(enum *buf*);
buf: NONE, FRONT, FRONT_{LEFT, RIGHT}, BACK, BACK_{LEFT, RIGHT}, LEFT, RIGHT, FRONT_AND_BACK, COLOR_ATTACHMENT*i* (where *i* is [0, MAX_COLOR_ATTACHMENTS - 1]), AUX*i* (where *i* is [0, AUX_BUFFERS - 1])
void **DrawBuffers**(sizei *n*, const enum **bufs*);
bufs: NONE, FRONT_{LEFT, RIGHT}, BACK_LEFT, BACK_RIGHT, COLOR_ATTACHMENT*i* (where *i* is [0, MAX_COLOR_ATTACHMENTS - 1]), AUX*i* (where *i* is [0, AUX_BUFFERS - 1])

Fine Control of Buffer Updates [4.2.2]

void **IndexMask**(uint *mask*);
void **ColorMask**(boolean *r*, boolean *g*, boolean *b*, boolean *a*);
void **ColorMaski**(uint *buf*, boolean *r*, boolean *g*, boolean *b*, boolean *a*);
void **DepthMask**(boolean *mask*);
void **StencilMask**(uint *mask*);
void **StencilMaskSeparate**(enum *face*, uint *mask*);
face: FRONT, BACK, FRONT_AND_BACK

Clearing the Buffers [4.2.3]

void **Clear**(bitfield *buf*);
buf: Bitwise OR of ACCUM_BUFFER_BIT, {COLOR, DEPTH, STENCIL}_BUFFER_BIT,
void **ClearColor**(clampf *r*, clampf *g*, clampf *b*, clampf *a*);
void **ClearIndex**(float *index*);
void **ClearDepth**(clampd *d*);
void **ClearStencil**(int *s*);
void **ClearAccum**(float *r*, float *g*, float *b*, float *a*);
void **ClearBuffer{if ui}v**(enum *buffer*, int *drawbuffer*, const T **value*)
buffer: COLOR, DEPTH, STENCIL
void **ClearBufferfi**(enum *buffer*, int *drawbuffer*, float *depth*, int *stencil*);
buffer: DEPTH_STENCIL
drawbuffer: 0

Accumulation Buffer [4.2.4]

void **Accum**(enum *op*, float *value*);
op: ACCUM, LOAD, RETURN, MULT, ADD.

Per-Fragment Operations

Scissor Test [4.1.2]

Enable/Disable(SCISSOR_TEST)
void **Scissor**(int *left*, int *bottom*, sizei *width*, sizei *height*);

Multisample Fragment Operations [4.1.3]

Enable/Disable(*target*)
target: SAMPLE_ALPHA_TO_{COVERAGE, ONE}, SAMPLE_{COVERAGE, MASK}, MULTISAMPLE
void **SampleCoverage**(clampf *value*, boolean *invert*);
void **SampleMaski**(uint *maskNumber*, bitfield *mask*);

Alpha Test [4.1.4]

Enable/Disable(ALPHA_TEST)
void **AlphaFunc**(enum *func*, clampf *ref*);
func: NEVER, ALWAYS, LESS,LEQUAL, EQUAL, GEQUAL, GREATER, NOTEQUAL

Stencil Test [4.1.4] [4.1.5]

Enable/Disable(STENCIL_TEST)
void **StencilFunc**(enum *func*, int *ref*, uint *mask*);
void **StencilFuncSeparate**(enum *face*, enum *func*, int *ref*, uint *mask*);
void **StencilOp**(enum *sfail*, enum *dpfail*, enum *dppass*);
void **StencilOpSeparate**(enum *face*, enum *sfail*, enum *dpfail*, enum *dppass*);
face: FRONT, BACK, FRONT_AND_BACK
sfail, dpfail, and *dppass:* KEEP, ZERO, REPLACE, INCR, DECR, INVERT, INCR_WRAP, DECR_WRAP
func: NEVER, ALWAYS, LESS, LEQUAL, EQUAL, GREATER, GEQUAL, NOTEQUAL

Depth Buffer Test [4.1.5] [4.1.6]

Enable/Disable(DEPTH_TEST)
void **DepthFunc**(enum *func*);
func: see StencilOpSeparate

Occlusion Queries [4.1.6] [4.1.7]

BeginQuery(enum *target*, uint *id*);
EndQuery(enum *target*);
target: SAMPLES_PASSED, ANY_SAMPLES_PASSED

Blending [4.1.7] [4.1.8]

Enable/Disable(BLEND)
Enablei/Disablei(BLEND, uint *index*)
void **BlendEquation**(enum *mode*);
void **BlendEquationi**(uint *buf*, enum *mode*);
void **BlendEquationSeparate**(enum *modeRGB*, enum *modeAlpha*);
mode, modeRGB, and *modeAlpha:* FUNC_ADD, FUNC_{SUBTRACT, REVERSE}_SUBTRACT, MIN, MAX
void **BlendEquationSeparatei**(uint *buf*, enum *modeRGB*, enum *modeAlpha*);
mode, modeRGB, and *modeAlpha:* see BlendEquationSeparate
void **BlendFunc**(enum *src*, enum *dst*);
srd, dst: see BlendFuncSeparate
void **BlendFunci**(uint *buf*, enum *src*, enum *dst*);
srd, dst: see BlendFuncSeparate
void **BlendFuncSeparate**(enum *srcRGB*, enum *dstRGB*, enum *srcAlpha*, enum *dstAlpha*);
src, dst, *srcRGB, dstRGB, srcAlpha, dstAlpha:* ZERO, ONE, {SRC, DST, CONSTANT}_{COLOR, ALPHA}, ONE_MINUS_ {SRC, DST, CONSTANT}_{COLOR, ALPHA}, SRC_ALPHA_SATURATE, {ONE_MINUS_}SRC1_ALPHA
void **BlendFuncSeparatei**(uint *buf*, enum *srcRGB*, enum *dstRGB*, enum *srcAlpha*, enum *dstAlpha*);
dst, dstRGB, dstAlpha, src, *srcRGB, srcAlpha:* see BlendFuncSeparate
void **BlendColor**(clampf *red*, clampf *green*, clampf *blue*, clampf *alpha*);

Dithering [4.1.9] [4.1.10]

Enable/Disable(DITHER)

Logical Operation [4.1.10] [4.1.11]

Enable/Disable(enum *op*)
op: INDEX_LOGIC_OP, LOGIC_OP, COLOR_LOGIC_OP
void **LogicOp**(enum *op*);
op: CLEAR, AND, AND_REVERSE, COPY, AND_INVERTED, NOOP, OR, OR, NOR, EQUIV, INVERT, OR_REVERSE, COPY_INVERTED, OR_INVERTED, NAND, SET

OpenGL 4.00 API Quick Reference Card

Framebuffer Objects

Binding and Managing [4.4.1]

void **BindFramebuffer**(enum *target*, uint *framebuffer*);
target: {DRAW, READ_}FRAMEBUFFER

void **DeleteFramebuffers**(sizei *n*, uint **framebuffers*);

void **GenFramebuffers**(sizei *n*, uint **ids*);

Attaching Images [4.4.2]

Renderbuffer Objects

void **BindRenderbuffer**(enum *target*, uint *renderbuffer*);
target: RENDERBUFFER

void **DeleteRenderbuffers**(sizei *n*, const uint **renderbuffers*);

void **GenRenderbuffers**(sizei *n*, uint **renderbuffers*);

void **RenderbufferStorageMultisample**(enum *target*, sizei *samples*, enum *internalformat*, sizei *width*, sizei *height*);
target: RENDERBUFFER
internalformat: see TexImage2DMultisample

void **RenderbufferStorage**(enum *target*, enum *internalformat*, sizei *width*, sizei *height*);
target and *internalformat:* see RenderbufferStorageMultisample

Attaching Renderbuffer Images

void **FramebufferRenderbuffer**(enum *target*, enum *attachment*, enum *renderbuffertarget*, uint *renderbuffer*);
target: {DRAW, READ_}FRAMEBUFFER
attachment: {DEPTH, STENCIL}_ATTACHMENT, DEPTH_STENCIL_ATTACHMENT, COLOR_ATTACHMENT*i* (where *i* is [0, MAX_COLOR_ATTACHMENTS - 1])
renderbuffertarget: RENDERBUFFER

Attaching Texture Images

void **FramebufferTexture**(enum *target*, enum *attachment*, uint *texture*, int *level*);
target: {DRAW, READ_}FRAMEBUFFER
attachment: see FramebufferRenderbuffer

void **FramebufferTexture3D**(enum *target*, enum *attachment*, enum *textarget*, uint *texture*, int *level*, int *layer*);
textarget: TEXTURE_3D
target and *attachment:* see FramebufferRenderbuffer

void **FramebufferTexture2D**(enum *target*, enum *attachment*, enum *textarget*, uint *texture*, int *level*);
textarget: TEXTURE_{RECTANGLE, 3D}, TEXTURE_2D_MULTISAMPLE{_ARRAY}, TEXTURE_CUBE_MAP_{POSITIVE, NEGATIVE}_{X, Y, Z}
target, attachment: see FramebufferRenderbuffer

void **FramebufferTexture1D**(enum *target*, enum *attachment*, enum *textarget*, uint *texture*, int *level*);
textarget: TEXTURE_1D
target, attachment: see FramebufferRenderbuffer

void **FramebufferTextureLayer**(enum *target*, enum *attachment*, uint *texture*, int *level*, int *layer*);
target, attachment: see FramebufferTexture3D

Framebuffer Completeness [4.4.4]

enum **CheckFramebufferStatus**(enum *target*);
target: {DRAW, READ_}FRAMEBUFFER
returns: FRAMEBUFFER_COMPLETE or a constant indicating the violating value

Framebuffer Object Queries [6.1.13] [6.1.19]

boolean **IsFramebuffer**(uint *framebuffer*);

void **GetFramebufferAttachmentParameteriv**(enum *target*, enum *attachment*, enum *pname*, int **params*);
target: {DRAW, READ_}FRAMEBUFFER
attachment: FRONT_{LEFT, RIGHT}, BACK_{LEFT,RIGHT}, COLOR_ATTACHMENT*i*, AUX*i*, DEPTH, STENCIL, {DEPTH, STENCIL}_ATTACHMENT, DEPTH_STENCIL_ATTACHMENT
pname: FRAMEBUFFER_ATTACHMENT_*x* (where *x* may be OBJECT_TYPE, OBJECT_NAME, RED_SIZE, GREEN_SIZE, BLUE_SIZE, ALPHA_SIZE, DEPTH_SIZE, STENCIL_SIZE, COMPONENT_TYPE, COLOR_ENCODING, TEXTURE_LEVEL, LAYERED, TEXTURE_CUBE_MAP_FACE, TEXTURE_LAYER)

Renderbuffer Object Queries [6.1.14] [6.1.20]

boolean **IsRenderbuffer**(uint *renderbuffer*);

void **GetRenderbufferParameteriv**(enum *target*, enum *pname*, int **params*);
target: RENDERBUFFER
pname: RENDERBUFFER_*x* (where *x* may be WIDTH, HEIGHT, INTERNAL_FORMAT, SAMPLES, {RED, GREEN, BLUE, ALPHA, DEPTH, STENCIL}_SIZE)

Special Functions

Evaluators [5.1]

void **Map1{fd}**(enum *target*, T *u1*, T *u2*, int *stride*, int *order*, T *points*);
target: MAP1_VERTEX_{3,4}, MAP1_{INDEX, NORMAL}, MAP1_COLOR_4, MAP1_TEXTURE_COORD_{1,2,3,4}

void **Map2{fd}**(enum *target*, T *u1*, T *u2*, int *ustride*, int *uorder*, T *v1*, T *v2*, int *vstride*, int *vorder*, T *points*);
target: see Map1, BUT replace MAP1 with MAP2

void **EvalCoord{12}{fd}**(T *arg*);

void **EvalCoord{12}{fd}v**(T *arg*);

void **MapGrid1{fd}**(int *n*, T *u1*, T *u2*);

void **MapGrid2{fd}**(int *nu*, T *u1*, T *u2*, int *nv*, T *v1*, T *v2*);

void **EvalMesh1**(enum *mode*, int *p1*, int *p2*);
mode: POINT, LINE

void **EvalMesh2**(enum *mode*, int *p1*, int *p2*, int *q1*, int *q2*);
mode: FILL, POINT, LINE

void **EvalPoint1**(int *p*);

void **EvalPoint2**(int *p*, int *q*);

Enumerated Query [6.1.3]

void **GetMap{ifd}v**(enum *map*, enum *value*, T *data*);
map: see target for Map1
value: ORDER, COEFF, DOMAIN

Selection [5.2]

void **InitNames**(void);

void **PopName**(void);

void **PushName**(uint *name*);

void **LoadName**(uint *name*);

int **RenderMode**(enum *mode*);
mode: RENDER, SELECT, FEEDBACK

void **SelectBuffer**(sizei *n*, uint **buffer*);

Feedback [5.3]

void **FeedbackBuffer**(sizei *n*, enum *type*, float **buffer*);
type: 2D, 3D, 3D_COLOR, 3D_COLOR_TEXTURE, 4D_COLOR_TEXTURE

void **PassThrough**(float *token*);

Timer Queries [5.1] [5.4]

void **QueryCounter**(uint *id*, TIMESTAMP);

void **GetInteger64v**(TIMESTAMP, int64 **data*);

Display Lists [5.5]

void **NewList**(uint *n*, enum *mode*);
mode: COMPILE, COMPILE_AND_EXECUTE

void **EndList**(void);

void **CallList**(uint *n*);

void **CallLists**(sizei *n*, enum *type*, void **lists*);
type: BYTE, UNSIGNED_BYTE, SHORT, {2,3,4}_BYTES, UNSIGNED_SHORT, INT, UNSIGNED_INT, FLOAT

void **ListBase**(uint *base*);

uint **GenLists**(sizei *s*);

boolean **IsList**(uint *list*);

void **DeleteLists**(uint *list*, sizei *range*);

Synchronization

Flush and Finish [5.2] [5.6]

void **Flush**(void);

void **Finish**(void);

Sync Objects and Fences [5.3] [5.7]

sync **FenceSync**(enum *condition*, bitfield *flags*)
condition: SYNC_GPU_COMMANDS_COMPLETE
flags: must be 0

void **DeleteSync**(sync *sync*);

Waiting for Sync Objects [5.31] [5.7.1]

enum **ClientWaitSync**(sync *sync*, bitfield *flags*, uint64 *timeout_ns*);
flags: SYNC_FLUSH_COMMANDS_BIT, or zero

void **WaitSync**(sync *sync*, bitfield *flags*, uint64 *timeout_ns*);
timeout_ns: TIMEOUT_IGNORED

Sync Object Queries [6.1.8] [6.1.14]

void **GetSynciv**(sync *sync*, enum *pname*, sizei *bufSize*, sizei **length*, int **values*);
pname: OBJECT_TYPE, SYNC_{STATUS,CONDITION, FLAGS}

boolean **IsSync**(sync *sync*);

State and State Requests

A complete list of symbolic constants for states is shown in the tables in [6.2].

Simple Queries [6.1.1]

void **GetBooleanv**(enum *pname*, boolean **data*);

void **GetIntegerv**(enum *pname*, int **data*);

void **GetInteger64v**(enum *pname*, int64 **data*);

void **GetFloatv**(enum *pname*, float **data*);

void **GetDoublev**(enum *pname*, double **data*);

void **GetBooleani_v**(enum *target*, uint *index*, boolean **data*);

void **GetIntegeri_v**(enum *target*, uint *index*, int **data*);

void **GetInteger64i_v**(enum *target*, uint *index*, int64 **data*);

boolean **IsEnabled**(enum *cap*);

boolean **IsEnabledi**(enum *target*, uint *index*);

Pointer & String Queries [6.1.6] [6.1.12]

void **GetPointerv**(enum *pname*, void ***params*);
pname: {SELECTION, FEEDBACK}_BUFFER_POINTER, {VERTEX, NORMAL, COLOR}_ARRAY_POINTER, {SECONDARY_COLOR, INDEX}_ARRAY_POINTER, {TEXTURE, FOG}_COORD_ARRAY_POINTER, EDGE_FLAG_ARRAY_POINTER

ubyte ***GetString**(enum *name*);
name: RENDERER, VENDOR, VERSION, SHADING_LANGUAGE_VERSION, EXTENSIONS

ubyte ***GetStringi**(enum *name*, uint *index*);
name: EXTENSIONS
index: range is [0, NUM_EXTENSIONS - 1]

Saving and Restoring State [6.1.21]

void **PushAttrib**(bitfield *mask*);
mask: ALL_ATTRIB_BITS, or the bitwise OR of the attribute groups in [Table 6.3].

void **PushClientAttrib**(bitfield *mask*);
mask: CLIENT_ALL_ATTRIB_BITS, or the bitwise OR of the attribute groups in [Table 6.3].

void **PopAttrib**(void);

void **PopClientAttrib**(void);

The OpenGL® Shading Language is used to create shaders for each of the programmable processors contained in the OpenGL processing pipeline.

[n.n.n] and **[Table n.n]** refer to sections and tables in the OpenGL Shading Language 4.00 specification at www.opengl.org/registry

Content shown in blue is removed from the OpenGL 4.00 core profile and present only in the OpenGL 4.00 compatibility profile.

Preprocessor [3.3]

Preprocessor Operators

Preprocessor operators follow C++ standards. Preprocessor expressions are evaluated according to the behavior of the host processor, not the processor targeted by the shader.

Preprocessor Directives

Each number sign (#) can be preceded in its line only by spaces or horizontal tabs.

#	#define	#undef	#if
#ifdef	#ifndef	#else	#elif
#endif	#error	#pragma	#line
#extension	#version	#include	

#version 400 #version 400 *profile*	"#version 400" is required in shaders using version 4.00 of the language. Use *profile* to indicate core or compatibilty. if no *profile* specified, the default is core.
#extension *extension_name* : *behavior* #extension all : *behavior*	• *behavior*: require, enable, warn, disable • *extension_name:* the extension supported by the compiler, or "all"

Predefined Macros

__LINE__ __FILE__	Decimal integer constants. FILE says which source string number is currently being processed, or the path of the string if the string was an included string
GL_compatibility_profile	Integer 1 if the implementation supports the compatibility profile
__VERSION__	Decimal integer, e.g.: 400

Operators and Expressions [5.1]

Numbered in order of precedence. Relational and equality operators > < <= >= == != evaluate to Boolean. Compare vectors component-wise with functions such as lessThan(), equal(), etc.

1.	( )	parenthetical grouping
2.	[ ] ( ) . ++ --	array subscript function call & constructor structure field or method selector, swizzler postfix increment and decrement
3.	++ -- + - ~ !	prefix increment and decrement unary
4.	* / %	multiplicative
5.	+ -	additive
6.	<< >>	bit-wise shift
7.	< > <= >=	relational
8.	== !=	equality
9.	&	bit-wise and
10.	^	bit-wise exclusive or
11.	|	bit-wise inclusive or
12.	&&	logical and
13.	^^	logical exclusive or
14.	| |	logical inclusive or
15.	? :	Selects an entire operand. Use **mix**() to select indiv. components of vectors.
16.	= += -= *= /= %= <<= >>= &= ^= |=	assignment arithmetic assignments
17.	,	sequence

Vector Components [5.5]

In addition to array numeric subscript syntax, names of vector components denoted by a single letter. Components can be swizzled and replicated.

{*x, y, z, w*}	Vectors representing points or normals
{*r, g, b, a*}	Vectors representing colors
{*s, t, p, q*}	Vectors representing texture coordinates

Aggregate Operations and Constructors

Matrix Constructor Examples [5.4]

```
mat2(vec2, vec2);                  // 1 col./arg.
mat2x3(vec2, float, vec2, float);  // col. 2
dmat2(dvec2, dvec2);               // 1 col./arg.
dmat3(dvec3, dvec3, dvec3);        // 1 col./arg.
```

Array Constructor Example [5.4]

```
float c[3] = float[3](5.0, b + 1.0, 1.1);
```

Structure Constructor Example [5.4]

```
struct light {members; };
light lightVar = light(3.0, vec3(1.0, 2.0, 3.0));
```

Matrix Component Examples [5.6]

Examples of access components of a matrix with array subscripting syntax:

```
mat4 m;
m[1] = vec4(2.0);  // sets 2nd col. to all 2.0
m[0][0] = 1.0;     // sets upper left element to 1.0
m[2][3] = 2.0;     // sets 4th element of 3rd col. to 2.0
```

Examples of operations on matrices and vectors:

```
m = f * m;     // scalar * matrix component-wise
v = f * v;     // scalar * vector component-wise
v = v * v;     // vector * vector component-wise
m = m +/- m;   // matrix +/- matrix comp.-wise
m = m * m;     // linear algebraic multiply
f = dot(v, v); // vector dot product
v = cross(v, v); // vector cross product
```

OpenGL Shading Language 4.00 Quick Reference Card

Types [4.1.1-4.1.10]

Transparent Types

void	no function return value
bool	Boolean
int, uint	signed/unsigned integers
float	single-precision floating-point scalar
double	double-precision floating scalar
vec2, vec3, vec4	floating point vector
dvec2, dvec3, dvec4	double precision floating-point vectors
bvec2, bvec3, bvec4	Boolean vectors
ivec2, ivec3, ivec4 uvec2, uvec3, uvec4	signed and unsigned integer vectors
mat2, mat3, mat4	2x2, 3x3, 4x4 float matrix
mat2x2, mat2x3, mat2x4	2-column float matrix of 2, 3, or 4 rows
mat3x2, mat3x3, mat3x4	3-column float matrix of 2, 3, or 4 rows
mat4x2, mat4x3, mat4x4	4-column float matrix of 2, 3, or 4 rows
dmat2, dmat3, dmat4	2x2, 3x3, 4x4 double-precision float matrix
dmat2x2, dmat2x3, dmat2x4	2-col. double-precision float matrix of 2, 3, 4 rows
dmat3x2, dmat3x3, dmat3x4	3-col. double-precision float matrix of 2, 3, 4 rows
dmat4x2, dmat4x3, dmat4x4	4-column double-precision float matrix of 2, 3, 4 rows

Floating-Point Sampler Types (Opaque)

sampler[1,2,3]D	1D, 2D, or 3D texture
samplerCube	cube mapped texture
sampler2DRect	rectangular texture
sampler[1,2]DShadow	1D,2D depth texture/ compare
sampler2DRectShadow	rectangular texture/ comparison
sampler[1,2]DArray	1D or 2D array texture
sampler[1,2]DArrayShadow	1D or 2D array depth texture/comparison
samplerBuffer	buffer texture
sampler2DMS	2D multi-sample texture
sampler2DMSArray	2D multi-sample array tex.
samplerCubeArray	cube map array texture
samplerCubeArrayShadow	cube map array depth texture with comparison

Integer Sampler Types (Opaque)

isampler[1,2,3]D	integer 1D, 2D, or 3D texture
isamplerCube	integer cube mapped texture
isampler2DRect	int. 2D rectangular texture
isampler[1,2]DArray	integer 1D, 2D array texture
isamplerBuffer	integer buffer texture
isampler2DMS	int. 2D multi-sample texture
isampler2DMSArray	int. 2D multi-sample array tex.
isamplerCubeArray	int. cube map array texture

Unsigned Integer Sampler Types (Opaque)

usampler[1,2,3]D	uint 1D, 2D, or 3D texture
usamplerCube	uint cube mapped texture
usampler2DRect	uint rectangular texture
usampler[1,2]DArray	1D or 2D array texture
usamplerBuffer	uint buffer texture
usampler2DMS	uint 2D multi-sample texture
usampler2DMSArray	uint 2D multi-sample array tex.
usamplerCubeArray	uint cube map array texture

Implicit Conversions (All others must use constructors)

int	->	uint
int, uint	->	float
int, uint, float	->	double
ivec2|3|4	->	uvec2|3|4
ivec2|3|4	->	vec2|3|4
uvec2|3|4	->	vec2|3|4
vec2|3|4	->	dvec2|3|4
ivec2|3|4	->	dvec2|3|4
uvec2|3|4	->	dvec2|3|4
mat2|3|4	->	dmat2|3|4
mat2x3|2x4	->	dmat2x3|2x4
mat3x2|3x4	->	dmat3x2|3x4
mat4x2|4x3	->	dmat4x2|4x3

Aggregation of Basic Types

Arrays	**float**[3] foo; **float** foo[3]; • structures and blocks can be arrays • supports only 1-dimensional arrays • structure members can be arrays

Structures	**struct** *type-name* {
	members
	} *struct-name*[];
	// optional variable declaration, optionally an array

Blocks	**in/out/uniform** *block-name* {
	// interface matching by block name
	optionally-qualified members
	} *instance-name*[];
	// optional instance name,optionally an array

Structure & Array Operations [5.7]

Select structure fields and the length() method of an array using the period (.) operator. Other operators include:

.	field or method selector
== !=	equality
=	assignment
[ ]	indexing (arrays only)

Array elements are accessed using the array subscript operator ([ ]), e.g.:

```
diffuseColor += lightIntensity[3]*NdotL;
```

Qualifiers

Storage Qualifiers [4.3]

Declarations may have one storage qualifier.

none	(default) local read/write memory, or input parameter
const	compile-time constant, or read-only function parameter
in **centroid in** **sample in**	linkage into shader from previous stage linkage w/centroid based interpolation input linkage w/per-sample interpolation
out **centroid out** **sample out**	linkage out of a shader to next stage linkage w/centroid based interpolation output linkage w/per-sample interpolation
attribute ‡	linkage between a vertex shader and OpenGL for per-vertex data
uniform	linkage between a shader, OpenGL, and the application
varying ‡ **centroid varying** ‡	linkage between a vertex shader and a fragment shader for interpolated data
patch in **patch out**	tessellation eval. shader input tessellation control shader output

‡ Qualifier is deprecated but not removed from core specification.

Uniform Qualifiers [4.3.5]

Declare global variables with same values across entire primitive processed.

```
uniform vec4 lightPosition;
```

Layout Qualifiers [4.3.8]

layout(*layout-qualifiers*) *block-declaration*

layout(*layout-qualifiers*) **in/out/uniform**

layout(*layout-qualifiers*) **in/out/uniform** *declaration*

Input Layout Qualifiers

For tessellation evaluation shaders:

triangles, quads, equal_spacing, isolines, fractional_{even,odd}_spacing, cw, ccw, point_mode

For geometry shader inputs:

points, lines, {lines,triangles}_adjacency, triangles, invocations = *integer-constant*

Input layout in fragment shaders only for redeclaring built-in variable gl_FragCoord:

origin_upper_left, pixel_center_integer

Output Layout Qualifiers

For tessellation control shaders:

vertices = *integer-constant*

For geometry shader outputs:

points, line_strip, triangle_strip, max_vertices = *integer-constant*, stream = *integer-constant*

For fragment shaders:

location = *integer-constant*, index = *integer-constant*

Uniform-Block Layout Qualifiers

Layout qualifier identifiers for uniform blocks:

shared, packed, std140, {row, column}_major,

Interpolation Qualifier [4.3.9]

Qualify outputs from vertex shader and inputs to fragment shader.

smooth	perspective correct interpolation
flat	no interpolation
noperspective	linear interpolation

The following predeclared variables can be redeclared with an interpolation qualifier:

Vertex language:	**Fragment language:**
gl_FrontColor	gl_Color
gl_BackColor	gl_SecondaryColor
gl_FrontSecondaryColor	
gl_BackSecondaryColor	

Parameter Qualifiers [4.4]

Input values copied in at function call time, output values copied out at function return time.

none	(default) same as **in**
in	for function parameters passed into function
out	for function parameters passed back out of function, but not initialized when passed in
inout	for function parameters passed both into and out of a function

Precision and Precision Qualifiers [4.5]

Precision qualifiers have no effect on precision; they aid code portability with OpenGL ES:

highp, mediump, lowp

Invariant Qualifiers Examples [4.6]

#pragma STDGL invariant(all)	force all output variables to be invariant
invariant gl_Position;	qualify a previously declared variable
invariant centroid out vec3 Color;	qualify as part of a variable declaration

Precise Qualifier [4.7]

Ensures that operations contributing to a variable's value are executed in their stated order and done with operator consistency. Requires two identical multiplies, followed by an add.

```
precise out vec4 Position = a * b + c * d;
```

Order of Qualification [4.8]

When multiple qualifications are present, they must follow this strict order:

precise invariant interpolation storage precision storage parameter precision

Statements and Structure

Iteration and Jumps [6]

Function Call	call by value-return

Iteration	for (;;) { break, continue }
	while ( ) { break, continue }
	do { break, continue } while ( );

Selection	if ( ) { }
	if ( ) { } else { }
	switch ( ) { case integer: ... break; ... default: ... }

Entry	void main()
Jump	break, continue, return (There is no 'goto')
Exit	return in main() discard // Fragment shader only

Subroutines [6.1.2]

Declare types with the **subroutine** keyword:

```
subroutine returnType subroutineTypeName(type0 arg0, type1 arg1, ..., typen argn);
```

Associate functions with subroutine types of matching declarations by defining the functions with the subroutine keyword and a list of subroutine types the function matches:

```
subroutine(subroutineTypeName0, ..., subroutineTypeNameN)
returnType functionName(type0 arg0, type1 arg1, ..., typen argn){ ... }   // function body
```

Declare subroutine type variables with a specific subroutine type in a subroutine uniform variable declaration:

```
subroutine uniform subroutineTypeName subroutineVarName;
```

Subroutine type variables are assigned to functions through commands (**UniformSubroutinesuiv**) in the OpenGL API.

Built-In Variables [7]

Vertex Language

```
Inputs:
  in int   gl_VertexID;
  in int   gl_InstanceID;
  in vec4  gl_Color;
  in vec4  gl_SecondaryColor;
  in vec3  gl_Normal;
  in vec4  gl_Vertex;
  in vec4  gl_MultiTexCoordn          // n is 0...7
  in float gl_FogCoord;
Outputs:
  out gl_PerVertex {
    vec4  gl_Position;
    float gl_PointSize;
    float gl_ClipDistance[];
    vec4  gl_ClipVertex;
    vec4  gl_FrontColor;
    vec4  gl_BackColor;
    vec4  gl_FrontSecondaryColor;
    vec4  gl_BackSecondaryColor;
    vec4  gl_TexCoord[];
    float gl_FogFragCoord;
  };
```

Tessellation Control Language

```
Inputs:
  in gl_PerVertex {
    vec4  gl_Position;
    float gl_PointSize;
    float gl_ClipDistance[];
    (... also deprecated Vertex Language Outputs)
  } gl_in[gl_MaxPatchVertices];

  in int  gl_PatchVerticesIn;
  in int  gl_PrimitiveID;
  in int  gl_InvocationID;
```

Tessellation Control Language (cont'd)

```
Outputs:
  out gl_PerVertex {
    vec4  gl_Position;
    float gl_PointSize;
    float gl_ClipDistance[];
    (... also deprecated Vertex Language Outputs)
  } gl_out[];

  patch out float gl_TessLevelOuter[4];
  patch out float gl_TessLevelInner[2];
```

Tessellation Evaluation Language

```
Inputs:
  in gl_PerVertex {
    vec4  gl_Position;
    float gl_PointSize;
    float gl_ClipDistance[];
    (... also deprecated Vertex Language Outputs)
  } gl_in[gl_MaxPatchVertices];

  in int   gl_PatchVerticesIn;
  in int   gl_PrimitiveID;
  in vec3  gl_TessCoord;
  patch in float gl_TessLevelOuter[4];
  patch in float gl_TessLevelInner[2];
Outputs:
  out gl_PerVertex {
    vec4  gl_Position;
    float gl_PointSize;
    float gl_ClipDistance[];
    (... also deprecated Vertex Language Outputs)
  };
```

Geometry Language

```
Inputs:
  in gl_PerVertex {
    vec4  gl_Position;
    float gl_PointSize;
```

Geometry Language (cont'd)

```
    float gl_ClipDistance[];
    (... also deprecated Vertex Language Outputs)
  } gl_in[];

  in int gl_PrimitiveIDIn;
  in int gl_InvocationID;
Outputs:
  out gl_PerVertex {
    vec4 gl_Position;
    float gl_PointSize;
    float gl_ClipDistance[];
    (... also deprecated Vertex Language Outputs)
  };

  out int gl_PrimitiveID;
  out int gl_Layer;
```

Fragment Language

```
Inputs:
  in vec4  gl_FragCoord;
  in bool  gl_FrontFacing;
  in float gl_ClipDistance[];
  in vec2  gl_PointCoord;
  in int   gl_PrimitiveID;
  in int   gl_SampleID;
  in vec2  gl_SamplePosition;
  in float gl_FogFragCoord;
  in vec4  gl_TexCoord[];
  in vec4  gl_Color;
  in vec4  gl_SecondaryColor;
Outputs:
  out vec4 gl_FragColor;
  out vec4 gl_FragData[gl_MaxDrawBuffers];
  out float gl_FragDepth;
  out int  gl_SampleMask[];
```

(Continued >)

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Built-In Variables (continued)

Built-In Constants [7.3]

The following built-in constants with minimum values are provided to all shaders. The actual values used are implementation dependent, but must be at least the value shown.

```
const int gl_MaxTextureUnits = 2;
const int gl_MaxTextureCoords = 8;
const int gl_MaxClipPlanes = 8;
const int gl_MaxVertexAttribs = 16;
const int gl_MaxVertexUniformComponents = 1024;
const int gl_MaxVaryingFloats = 60;
const int gl_MaxVaryingComponents = 60;
const int gl_MaxVertexOutputComponents = 64;
const int gl_MaxGeometryInputComponents = 64;
const int gl_MaxGeometryOutputComponents = 128;
const int gl_MaxFragmentInputComponents = 128;
const int gl_MaxVertexTextureImageUnits = 16;
const int gl_MaxCombinedTextureImageUnits = 80;
const int gl_MaxTextureImageUnits = 16;
const int gl_MaxFragmentUniformComponents = 1024;
const int gl_MaxDrawBuffers = 8;
const int gl_MaxClipDistances = 8;
const int gl_MaxGeometryTextureImageUnits = 16;
const int gl_MaxGeometryOutputVertices = 256;
const int gl_MaxGeometryTotalOutputComponents = 1024;
const int gl_MaxGeometryUniformComponents = 1024;
const int gl_MaxGeometryVaryingComponents = 64;
const int gl_MaxTessControlInputComponents = 128;
const int gl_MaxTessControlOutputComponents = 128;
const int gl_MaxTessControlTextureImageUnits = 16;
const int gl_MaxTessControlUniformComponents = 1024;
const int gl_MaxTessControlTotalOutputComponents = 4096;
const int gl_MaxTessEvaluationInputComponents = 128;
const int gl_MaxTessEvaluationOutputComponents = 128;
const int gl_MaxTessEvaluationTextureImageUnits = 16;
const int gl_MaxTessEvaluationUniformComponents = 1024;
const int gl_MaxTessPatchComponents = 120;
const int gl_MaxPatchVertices = 32;
const int gl_MaxTessGenLevel = 64;
```

Built-In Functions

Angle & Trig. Functions [8.1]

Functions will not result in a divide-by-zero error. If the divisor of a ratio is 0, then results will be undefined. Component-wise operation. Parameters specified as *angle* are in units of radians. Tf=float, vec*n*.

Tf **radians**(Tf *degrees*)	degrees to radians
Tf **degrees**(Tf *radians*)	radians to degrees
Tf **sin**(Tf *angle*)	sine
Tf **cos**(Tf *angle*)	cosine
Tf **tan**(Tf *angle*)	tangent
Tf **asin**(Tf *x*)	arc sine
Tf **acos**(Tf *x*)	arc cosine
Tf **atan**(Tf *y*, Tf *x*) Tf **atan**(Tf *y_over_x*)	arc tangent
Tf **sinh**(Tf *x*)	hyperbolic sine
Tf **cosh**(Tf *x*)	hyperbolic cosine
Tf **tanh**(Tf *x*)	hyperbolic tangent
Tf **asinh**(Tf *x*)	hyperbolic sine
Tf **acosh**(Tf *x*)	hyperbolic cosine
Tf **atanh**(Tf *x*)	hyperbolic tangent

Exponential Functions [8.2]

Component-wise operation. Tf=float, vec*n*. Tfd= float, vec*n*, double, dvec*n*.

Tf **pow**(Tf *x*, Tf *y*)	x^y
Tf **exp**(Tf *x*)	e^x
Tf **log**(Tf *x*)	ln
Tf **exp2**(Tf *x*)	2^x
Tf **log2**(Tf *x*)	$\log_2$
Tfd **sqrt**(Tfd *x*)	square root
Tfd **inversesqrt**(Tfd *x*)	inverse square root

Common Functions [8.3]

Component-wise operation. See Type Abbreviations.

Tfd **abs**(Tfd *x*) Ti **abs**(Ti *x*)	absolute value
Tfd **sign**(Tfd *x*) Ti **sign**(Ti *x*)	returns -1.0, 0.0, or 1.0
Tfd **floor**(Tfd *x*)	nearest integer <= *x*
Tfd **trunc**(Tfd *x*)	nearest integer with absolute value <= absolute value of *x*

Type Abbreviations for Built-in Functions: Tf=float, vec*n*. Td =double, dvec*n*. Tfd= float, vec*n*, double, dvec*n*. Tb=bvec*n*, bool. Tvec=vec*n*, uvec*n*, ivec*n*. Tu=uint, uvec*n*. Ti=int, ivec*n*. Tui=int, ivec*n*, uint, uvec*n*.

Use of T*n* or T*nn* within each function call must be the same. In vector types, *n* is 2, 3, or 4.

Common Functions (continued)

Tfd **round**(Tfd *x*)	nearest integer, implementation-dependent rounding mode
Tfd **roundEven**(Tfd *x*)	nearest integer, 0.5 rounds to nearest even integer
Tfd **ceil**(Tfd *x*)	nearest integer >= *x*
Tfd **fract**(Tfd *x*)	*x* - floor(*x*)
Tfd **mod**(Tfd *x*, Tfd *y*) Tf **mod**(Tf *x*, float *y*) Td **mod**(Td *x*, double *y*)	modulus
Tfd **modf**(Tfd *x*, out Tfd *i*)	separate integer and fractional parts
Tfd **min**(Tfd *x*, Tfd *y*) Tf **min**(Tf *x*, float *y*) Td **min**(Td *x*, double *y*) Tui **min**(Tui *x*, Tui *y*) Ti **min**(Ti *x*, int *y*) Tu **min**(Tu *x*, uint *y*)	minimum value
Tfd **max**(Tfd *x*, Tfd *y*) Tf **max**(Tf *x*, float *y*) Td **max**(Td *x*, double *y*) Tui **max**(Tui *x*, Tui *y*) Ti **max**(Ti *x*, int *y*) Tu **max**(Tu *x*, uint *y*)	maximum value
Tfd **mix**(Tfd *x*, Tfd *y*, Tfd *a*) Tf **mix**(Tf *x*, Tf *y*, float *a*) Td **mix**(Td *x*, Td *y*, double *a*)	linear blend of *x* and *y*
Tfd **mix**(Tfd *x*, Tfd *y*, Tb *a*)	true if comps. in *a* select comps. from *y*, else from *x*
Tfd **step**(Tfd *edge*, Tfd *x*) Tf **step**(float *edge*, Tf *x*) Td **step**(double *edge*, Td *x*)	0.0 if *x* < *edge*, else 1.0
Tb **isnan**(Tfd *x*)	true if *x* is NaN
Tb **isinf**(Tfd *x*)	true if *x* is positive or negative infinity
Tfd **clamp**(Tfd *x*, Tfd *minVal*, Tfd *maxVal*) Tf **clamp**(Tf *x*, float *minVal*, float *maxVal*) Td **clamp**(Td *x*, double *minVal*, double *maxVal*) Tui **clamp**(Tui *x*, Tui *minVal*, Tui *maxVal*) Ti **clamp**(Ti *x*, int *minVal*, int *maxVal*) Tu **clamp**(Tu *x*, uint *minVal*, uint *maxVal*)	min(max(*x*, *minVal*), *maxVal*)
Tfd **smoothstep**(Tfd *edge0*, Tfd *edge1*, T *x*) Tf **smoothstep**(float *edge0*, float *edge1*, Tf *x*) Td **smoothstep**(double *edge0*, double *edge1*, Td *x*)	clip and smooth
Ti **floatBitsToInt**(Tf *value*) Tu **floatBitsToInt**(Tf *value*)	Returns signed int or uint value representing the encoding of a floating-point value.
Tf **intBitsToFloat**(Tui *value*)	Returns floating-point value of a signed int or uint encoding of a floating-point value.
Tfd **fma**(Tfd *a*, Tfd *b*, Tfd *c*)	Computes and returns a*b + c. Treated as a single operation when using **precise**.
Tfd **frexp**(Tfd *x*, out Ti *exp*)	Splits *x* into a floating-point significand in the range [0.5, 1.0) and an int. exp. of 2.
Tfd **ldexp**(Tfd *x*, in Ti *exp*)	Builds a floating-point number from *x* and the corresponding integral exponent of 2 in *exp*.

Floating-Point Pack/Unpack [8.4]

These do not operate component-wise.

uint **packUnorm2x16**(vec2 *v*) uint **packUnorm4x8**(vec4 *v*) uint **packSnorm4x8**(vec4 *v*)	Converts each component of *v* into 8- or 16-bit ints, then packs results into the returned 32-bit unsigned integer.
vec2 **unpackUnorm2x16** (uint *p*) vec4 **unpackUnorm4x8** (uint *p*) vec4 **unpackSnorm4x8** (uint *p*)	Unpacks 32-bit *p* into two 16-bit uints, or four 8-bit uints or signed ints. Then converts each component to a normalized float to generate a 2- or 4-component vector.
double **packDouble2x32** (uvec2 *v*)	Packs components of *v* into a 64-bit value and returns a double-precision value.
uvec2 **unpackDouble2x32** (double *v*)	Returns a 2-component vector representation of *v*.

Geometric Functions [8.5]

These functions operate on vectors as vectors, not component-wise. Tf=float, vec*n*. Td =double, dvec*n*. Tfd= float, vec*n*, double, dvec*n*.

float **length**(Tf *x*) double **length**(Td *x*)	length of vector
float **distance**(Tf *p0*, Tf *p1*) double **distance**(Td *p0*, Td *p1*)	distance between points
float **dot**(Tf *x*, Tf *y*) double **dot**(Td *x*, Td *y*)	dot product
vec3 **cross**(vec3 *x*, vec3 *y*) dvec3 **cross**(dvec3 *x*, dvec3 *y*)	cross product
Tf **normalize**(Tf *x*) Td **normalize**(Td *x*)	normalize vector to length 1
vec4 **ftransform**( )	invariant vertex transform
Tfd **faceforward**(Tfd *N*, Tfd *I*, Tfd *Nref*)	returns *N* if dot(*Nref*, *I*) < 0, else -*N*
Tfd **reflect**(Tfd *I*, Tfd *N*)	reflection direction I - 2 * dot(*N*,*I*) * *N*
Tfd **refract**(Tfd *I*, Tfd *N*, float *eta*)	refraction vector

Matrix Functions [8.6]

For the matrix functions, type *mat* is used in the single-precision floating point functions, and type *dmat* is used in the double-precision floating point functions.
N and *M* are 1, 2, 3, 4.

mat **matrixCompMult**(mat *x*, mat *y*) dmat **matrixCompMult**(dmat *x*, dmat *y*)	component-wise multiply
mat*N* **outerProduct**(vec*N* *c*, vec*N* *r*) dmat*N* **outerProduct**(dvec*N* *c*, dvec*N* *r*)	outer product (where N != M)
mat*NxM* **outerProduct**(vec*M* *c*, vec*N* *r*) dmat*NxM* **outerProduct**(dvec*M* *c*, dvec*N* *r*)	outer product
mat*N* **transpose**(mat*N* *m*) dmat*N* **transpose**(dmat*N* *m*)	transpose
mat*NxM* **transpose**(mat*MxN* *m*) dmat*NxM* **transpose**(dmat*MxN* *m*)	transpose (where N != M)
float **determinant**(mat*N* *m*) double **determinant**(dmat*N* *m*)	determinant
mat*N* **inverse**(mat*N* *m*) dmat*N* **inverse**(dmat*N* *m*)	inverse

Vector Relational Functions [8.7]

Compare *x* and *y* component-wise. Sizes of the input and return vectors for any particular call must match. Tvec=vec*n*, uvec*n*, ivec*n*.

bvec*n* **lessThan**(Tvec *x*, Tvec *y*)	<
bvec*n* **lessThanEqual**(Tvec *x*, Tvec *y*)	<=
bvec*n* **greaterThan**(Tvec *x*, Tvec *y*)	>
bvec*n* **greaterThanEqual**(Tvec *x*, Tvec *y*)	>=
bvec*n* **equal**(Tvec *x*, Tvec *y*) bvec*n* **equal**(bvec*n* *x*, bvec*n* *y*)	==
bvec*n* **notEqual**(Tvec *x*, Tvec *y*) bvec*n* **notEqual**(bvec*n* *x*, bvec*n* *y*)	!=
bool **any**(bvec*n* *x*)	true if any component of *x* is true
bool **all**(bvec*n* *x*)	true if all components of *x* are true
bvec*n* **not**(bvec*n* *x*)	logical complement of *x*

Integer Functions [8.8]

Component-wise operation. Tu=uint, uvec*n*. Ti=int, ivec*n*. Tui=int, ivec*n*, uint, uvec*n*.

Tu **uaddCarry** (Tu *x*, Tu *y*, out Tu *carry*)	Adds 32-bit uint*x* and *y*, returning the sum modulo 2^{32}.
Tu **usubBorrow** (Tu *x*, Tu *y*, out Tu *borrow*)	Subtracts *y* from *x*, returning the difference if non-negative, otherwise 2^{32} plus the difference.
void **umulExtended** (Tu *x*, Tu *y*, out Tu *msb*, out Tu *lsb*,) void **imulExtended** (Ti *x*, Ti *y*, out Ti *msb*, out Ti *lsb*,)	Multiplies 32-bit integers *x* and *y*, producing a 64-bit result.
Tui **bitfieldExtract** (Tui *value*, int *offset*, int *bits*)	Extracts bits [*offset*, *offset* + *bits* - 1] from *value*, returns them in the least significant bits of the result.
Tui **bitfieldInsert** (Tui *base*, Tui *insert*, int *offset*,int *bits*)	Returns the insertion the *bits* least-significant bits of *insert* into *base*.
Tui **bitfieldReverse** (Tui *value*)	Returns the reversal of the bits of *value*.
Ti **bitCount** (Tui *value*)	Returns the number of bits set to 1.
Ti **findLSB** (Tui *value*)	Returns bit number of least significant bit.
Ti **findMSB** (Tui *value*)	Returns bit number of most significant bit.

Texture Lookup Functions [8.9]

See next page

Fragment Processing Functions [8.10]

Available only in fragment shaders. Tf=float, vec*n*.

Derivative functions

Tf **dFdx**(Tf *p*)	derivative in *x*
Tf **dFdy**(Tf *p*)	derivative in *y*
Tf **fwidth**(Tf *p*)	sum of absolute derivative in *x* and *y*

Interpolation functions

Tf **interpolateAtCentroid** (Tf *interpolant*)	Return value of *interpolant* sampled inside pixel and the primitive.
Tf **interpolateAtSample** (Tf *interpolant*, int *sample*)	Return value of *interpolant* at the location of sample number *sample*.
Tf **interpolateAtOffset** (Tf *interpolant*, vec2 *offset*)	Return value of *interpolant* sampled at fixed offset *offset* pixel center.

Noise Functions [8.11]

Returns noise value. Available to fragment, geometry, and vertex shaders.

float **noise1**(Tf *x*)	
vec*n* **noise*n***(Tf *x*)	where *n* is 2, 3, or 4

Geometry Shader Functions [8.12]

Only available in geometry shaders.

void **EmitStreamVertex**(int *stream*)	Emits values of output variables to the current output primitive stream *stream*.
void **EndStreamPrimitive**(int *stream*)	Completes current output primitive stream *stream* and starts a new one.
void **EmitVertex**()	Emits values of output variables to the current output primitive.
void **EndPrimitive**()	Completes output primitive and starts a new one.

Shader Invocation Control [8.13]

Controls execution order of shader invocations. Available only to tessellation control shaders.

void **barrier**()	Synchronizes across shader invocations.

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Texture Functions [8.9]

Available to vertex, geometry, and fragment shaders. gvec4=vec4, ivec4, uvec4. gsampler* =sampler*, isampler*, usampler*.

Texture Query [8.9.1]

int **textureSize**(gsampler1D *sampler*, int *lod*)
ivec2 **textureSize**(gsampler2D *sampler*, int *lod*)
ivec3 **textureSize**(gsampler3D *sampler*, int *lod*)
ivec2 **textureSize**(samplerCube *sampler*, int *lod*)
int **textureSize**(sampler1DShadow *sampler*, int *lod*)
ivec2 **textureSize**(sampler2DShadow *sampler*, int *lod*)
ivec2 **textureSize**(samplerCubeShadow *sampler*, int *lod*)
ivec3 **textureSize**(samplerCubeArray *sampler*, int *lod*)
ivec3 **textureSize**(samplerCubeArrayShadow *sampler*, int *lod*)
ivec2 **textureSize**(gsampler2DRect *sampler*)
ivec2 **textureSize**(sampler2DRectShadow *sampler*)
ivec2 **textureSize**(gsampler1DArray *sampler*, int *lod*)
ivec3 **textureSize**(gsampler2DArray *sampler*, int *lod*)
ivec2 **textureSize**(sampler1DArrayShadow *sampler*, int *lod*)
ivec3 **textureSize**(sampler2DArrayShadow *sampler*, int *lod*)
int **textureSize**(gsamplerBuffer *sampler*)
ivec2 **textureSize**(gsampler2DMS *sampler*)
ivec2 **textureSize**(gsampler2DMSArray *sampler*)

vec2 **textureQueryLod**(gsampler1D *sampler*, float *P*)
vec2 **textureQueryLod**(gsampler2D *sampler*, vec2 *P*)
vec2 **textureQueryLod**(gsampler3D *sampler*, vec3 *P*)
vec2 **textureQueryLod**(gsamplerCube *sampler*, vec3 *P*)
vec2 **textureQueryLod**(gsampler1DArray *sampler*, float *P*)
vec2 **textureQueryLod**(gsampler2DArray *sampler*, vec2 *P*)
vec2 **textureQueryLod**(gsamplerCubeArray *sampler*, vec3 *P*)
vec2 **textureQueryLod**(sampler1DShadow *sampler*, float *P*)
vec2 **textureQueryLod**(sampler2DShadow *sampler*, vec2 *P*)
vec2 **textureQueryLod**(samplerCubeShadow *sampler*, vec3 *P*)
vec2 **textureQueryLod**(sampler1DArrayShadow *sampler*, float *P*)
vec2 **textureQueryLod**(sampler2DArrayShadow *sampler*, vec2 *P*)
vec2 **textureQueryLod**(samplerCubeArrayShadow *sampler*, vec3 *P*)

Texel Lookup Functions [8.9.2]

Use texture coordinate *P* to do a lookup in the texture bound to *sampler*.

gvec4 **texture** (gsampler1D *sampler*, float *P* [, float *bias*])
gvec4 **texture** (gsampler2D *sampler*, vec2 *P* [, float *bias*])
gvec4 **texture** (gsampler3D *sampler*, vec3 *P* [, float *bias*])
gvec4 **texture** (gsamplerCube *sampler*, vec3 *P* [, float *bias*])
float **texture** (sampler{1D,2D}Shadow *sampler*, vec3 *P* [, float *bias*])
float **texture** (samplerCubeShadow *sampler*, vec4 *P* [, float *bias*])
gvec4 **texture** (gsampler1DArray *sampler*, vec2 *P* [, float *bias*])
gvec4 **texture** (gsampler2DArray *sampler*, vec3 *P* [, float *bias*])
gvec4 **texture** (gsamplerCubeArray *sampler*, vec4 *P* [, float *bias*])
float **texture** (sampler1DArrayShadow *sampler*, vec3 *P* [, float *bias*])
float **texture** (sampler2DArrayShadow *sampler*, vec4 *P*)
gvec4 **texture** (gsampler2DRect *sampler*, vec2 *P*)
float **texture** (sampler2DRectShadow *sampler*, vec3 *P*)
float **texture** (gsamplerCubeArrayShadow *sampler*, vec4 *P*, float *compare*)

Texture lookup with projection.

gvec4 **textureProj** (gsampler1D *sampler*, vec{2,4} *P* [, float *bias*])
gvec4 **textureProj** (gsampler2D *sampler*, vec{3,4} *P* [, float *bias*])
gvec4 **textureProj** (gsampler3D *sampler*, vec4 *P* [, float *bias*])
float **textureProj** (sampler{1D,2D}Shadow *sampler*, vec4 *P* [, float *bias*])
gvec4 **textureProj** (gsampler2DRect *sampler*, vec{3,4} *P*)
float **textureProj** (sampler2DRectShadow *sampler*, vec4 *P*)

Texture lookup as in **texture** but with explicit LOD.

gvec4 **textureLod**(gsampler1D *sampler*, float *P*, float *lod*)
gvec4 **textureLod**(gsampler2D *sampler*, vec2 *P*, float *lod*)
gvec4 **textureLod**(gsampler3D *sampler*, vec3 *P*, float *lod*)
gvec4 **textureLod**(gsamplerCube *sampler*, vec3 *P*, float *lod*)
float **textureLod**(sampler{1D,2D}Shadow *sampler*, vec3 *P*, float *lod*)
gvec4 **textureLod**(gsampler1DArray *sampler*, vec2 *P*, float *lod*)
gvec4 **textureLod**(gsampler2DArray *sampler*, vec3 *P*, float *lod*)
float **textureLod**(sampler1DArrayShadow *sampler*, vec3 *P*, float *lod*)
gvec4 **textureLod** (gsamplerCubeArray *sampler*, vec4 *P*, float *lod*)

Offset added before texture lookup as in **texture**.

gvec4 **textureOffset** (gsampler1D *sampler*, float *P*, int *offset* [, float *bias*])
gvec4 **textureOffset** (gsampler2D *sampler*, vec2 *P*, ivec2 *offset* [, float *bias*])
gvec4 **textureOffset** (gsampler3D *sampler*, vec3 *P*, ivec3 *offset* [, float *bias*])
gvec4 **textureOffset** (gsampler2DRect *sampler*, vec2 *P*, ivec2 *offset*)
float **textureOffset** (sampler2DRectShadow *sampler*, vec3 *P*, ivec2 *offset*)
float **textureOffset** (sampler1DShadow *sampler*, vec3 *P*, int *offset* [, float *bias*])
float **textureOffset** (sampler2DShadow *sampler*, vec3 *P*, ivec2 *offset* [, float *bias*])
gvec4 **textureOffset** (gsampler1DArray *sampler*, vec2 *P*, int *offset* [, float *bias*])
gvec4 **textureOffset** (gsampler2DArray *sampler*, vec3 *P*, ivec2 *offset* [, float *bias*])
float **textureOffset** (sampler1DArrayShadow *sampler*, vec3 *P*, int *offset* [, float *bias*])

Use integer texture coordinate *P* to lookup a single texel from *sampler*.

gvec4 **texelFetch**(gsampler1D *sampler*, int *P*, int *lod*)
gvec4 **texelFetch**(gsampler2D *sampler*, ivec2 *P*, int *lod*)
gvec4 **texelFetch**(gsampler3D *sampler*, ivec3 *P*, int *lod*)
gvec4 **texelFetch**(gsampler2DRect *sampler*, ivec2 *P*)
gvec4 **texelFetch**(gsampler1DArray *sampler*, ivec2 *P*, int *lod*)
gvec4 **texelFetch**(gsampler2DArray *sampler*, ivec3 *P*, int *lod*)
gvec4 **texelFetch**(gsamplerBuffer *sampler*, int *P*)
gvec4 **texelFetch**(gsampler2DMS *sampler*, ivec2 *P*, int *sample*)
gvec4 **texelFetch**(gsampler2DMSArray *sampler*, ivec3 *P*, int *sample*)

Fetch single texel as in **texelFetch** offset by *offset* as described in **textureOffset**.

gvec4 **texelFetchOffset**(gsampler1D *sampler*, int *P*, int *lod*, int *offset*)
gvec4 **texelFetchOffset**(gsampler2D *sampler*, ivec2 *P*, int *lod*, ivec2 *offset*)
gvec4 **texelFetchOffset**(gsampler3D *sampler*, ivec3 *P*, int *lod*, ivec3 *offset*)
gvec4 **texelFetchOffset**(gsampler2DRect *sampler*, ivec2 *P*, ivec2 *offset*)
gvec4 **texelFetchOffset**(gsampler1DArray *sampler*, ivec2 *P*, int *lod*, int *offset*)
gvec4 **texelFetchOffset**(gsampler2DArray *sampler*, ivec3 *P*, int *lod*, ivec2 *offset*)

Projective lookup as described in **textureProj** offset by *offset* as described in **textureOffset**.

gvec4 **textureProjOffset**(gsampler1D *sampler*, vec{2,4} *P*, int *offset* [, float *bias*])
gvec4 **textureProjOffset**(gsampler2D *sampler*, vec{3,4} *P*, ivec2 *offset* [, float *bias*])
gvec4 **textureProjOffset**(gsampler3D *sampler*, vec4 *P*, ivec3 *offset* [, float *bias*])
gvec4 **textureProjOffset**(gsampler2DRect *sampler*, vec{3,4} *P*, ivec2 *offset*)
float **textureProjOffset**(sampler2DRectShadow *sampler*, vec4 *P*, ivec2 *offset*)
float **textureProjOffset**(sampler1DShadow *sampler*, vec4 *P*, int offset [, float *bias*])
float **textureProjOffset**(sampler2DShadow *sampler*, vec4 *P*, ivec2 *offset* [, float *bias*])

Offset texture lookup with explicit LOD. *See textureLod and textureOffset.*

gvec4 **textureLodOffset**(gsampler1D *sampler*, float *P*, float *lod*, int *offset*)
gvec4 **textureLodOffset**(gsampler2D *sampler*, vec2 *P*, float *lod*, ivec2 *offset*)
gvec4 **textureLodOffset**(gsampler3D *sampler*, vec3 *P*, float *lod*, ivec3 *offset*)
float **textureLodOffset**(sampler1DShadow *sampler*, vec3 *P*, float *lod*, int *offset*)
float **textureLodOffset**(sampler2DShadow *sampler*, vec3 *P*, float *lod*, ivec2 *offset*)
gvec4 **textureLodOffset**(gsampler1DArray *sampler*, vec2 *P*, float *lod*, int *offset*)
gvec4 **textureLodOffset**(gsampler2DArray *sampler*, vec3 *P*, float *lod*, ivec2 *offset*)
float **textureLodOffset**(sampler1DArrayShadow *sampler*, vec3 *P*, float *lod*, int *offset*)

Projective texture lookup with explicit LOD. *See textureLod and textureOffset.*

gvec4 **textureProjLod**(gsampler1D *sampler*, vec{2,4} *P*, float *lod*)
gvec4 **textureProjLod**(gsampler2D *sampler*, vec{3,4} *P*, float *lod*)
gvec4 **textureProjLod**(gsampler3D *sampler*, vec4 *P*, float *lod*)
float **textureProjLod**(sampler{1,2}DShadow *sampler*, vec4 *P*, float *lod*)

Offset projective texture lookup with explicit LOD. *See textureProj, textureLod, and textureOffset.*

gvec4 **textureProjLodOffset**(gsampler1D *sampler*, vec{2,4} *P*, float *lod*, int *offset*)
gvec4 **textureProjLodOffset**(gsampler2D *sampler*, vec{3,4} *P*, float *lod*, ivec2 *offset*)
gvec4 **textureProjLodOffset**(gsampler3D *sampler*, vec4 *P*, float *lod*, ivec3 *offset*)
float **textureProjLodOffset**(sampler1DShadow *sampler*, vec4 *P*, float *lod*, int *offset*)
float **textureProjLodOffset**(sampler2DShadow *sampler*, vec4 *P*, float *lod*, ivec2 *offset*)

Texture lookup as in **texture** but with explicit gradients.

gvec4 **textureGrad**(gsampler1D *sampler*, float *P*, float *dPdx*, float *dPdy*)
gvec4 **textureGrad**(gsampler2D *sampler*, vec2 *P*, vec2 *dPdx*, vec2 *dPdy*)
gvec4 **textureGrad**(gsampler3D *sampler*, vec3 *P*, vec3 *dPdx*, vec3 *dPdy*)
gvec4 **textureGrad**(gsamplerCube *sampler*, vec3 *P*, vec3 *dPdx*, vec3 *dPdy*)
gvec4 **textureGrad**(gsampler2DRect *sampler*, vec2 *P*, vec2 *dPdx*, vec2 *dPdy*)
float **textureGrad**(sampler2DRectShadow *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*)
float **textureGrad**(sampler1DShadow *sampler*, vec3 *P*, float *dPdx*, float *dPdy*)
float **textureGrad**(sampler2DShadow *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*)
gvec4 **textureGrad**(gsampler1DArray *sampler*, vec2 *P*, float *dPdx*, float *dPdy*)
gvec4 **textureGrad**(gsampler2DArray *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*)
float **textureGrad**(sampler1DArrayShadow *sampler*, vec3 *P*, float *dPdx*, float *dPdy*)
float **textureGrad**(sampler2DArrayShadow *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*)
gvec4 **textureGrad**(gsamplerCubeArray *sampler*, vec4 *P*, vec3 *dPdx*, vec3 *dPdy*)

Texture lookup with both explicit gradient and offset, as described in **textureGrad** and **textureOffset.**

gvec4 **textureGradOffset**(gsampler1D *sampler*, float *P*, float *dPdx*, float *dPdy*, int *offset*)
gvec4 **textureGradOffset**(gsampler2D *sampler*, vec2 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*)
gvec4 **textureGradOffset**(gsampler3D *sampler*, vec3 *P*, vec3 *dPdx*, vec3 *dPdy*, ivec3 *offset*)
gvec4 **textureGradOffset**(gsampler2DRect *sampler*, vec2 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*)
float **textureGradOffset**(sampler2DRectShadow *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*)
float **textureGradOffset**(sampler1DShadow *sampler*, vec3 *P*, float *dPdx*, float *dPdy*, int *offset*)
float **textureGradOffset**(sampler2DShadow *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*)
gvec4 **textureGradOffset**(gsampler1DArray *sampler*, vec2 *P*, float *dPdx*, float *dPdy*, int *offset*)
gvec4 **textureGradOffset**(gsampler2DArray *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*)
float **textureGradOffset**(sampler1DArrayShadow *sampler*, vec3 *P*, float *dPdx*, float *dPdy*, int *offset*)
float **textureGradOffset**(sampler2DArrayShadow *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*)

Texture lookup both projectively as in **textureProj**, and with explicit gradient as in **textureGrad**.

gvec4 **textureProjGrad**(gsampler1D *sampler*, vec{2,4} *P*, float *dPdx*, float *dPdy*)
gvec4 **textureProjGrad**(gsampler2D *sampler*, vec{3,4} *P*, vec2 *dPdx*, vec2 *dPdy*)
gvec4 **textureProjGrad**(gsampler3D *sampler*, vec4 *P*, vec3 *dPdx*, vec3 *dPdy*)

(more ⤵)

Texture lookup projectively, with gradient (continued)

gvec4 **textureProjGrad**(gsampler2DRect *sampler*, vec{3,4} *P*, vec2 *dPdx*, vec2 *dPdy*)
float **textureProjGrad**(sampler2DRectShadow *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*)
float **textureProjGrad**(sampler1DShadow *sampler*, vec4 *P*, float *dPdx*, float *dPdy*)
float **textureProjGrad**(sampler2DShadow *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*)

Texture lookup projectively and with explicit gradient as in **textureProjGrad**, as well as with offset as in **textureOffset.**

gvec4 **textureProjGradOffset**(gsampler1D *sampler*, vec{2,4} *P*, float *dPdx*, float *dPdy*, int *offset*)
gvec4 **textureProjGradOffset**(gsampler2D *sampler*, vec{3,4} *P*, vec2 *dPdx*, vec2 *dPdy*, vec2 *offset*)
gvec4 **textureProjGradOffset**(gsampler2DRect *sampler*, vec{3,4} *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*)
float **textureProjGradOffset**(sampler2DRectShadow *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*)
gvec4 **textureProjGradOffset**(gsampler3D *sampler*, vec4 *P*, vec3 *dPdx*, vec3 *dPdy*, vec3 *offset*)
float **textureProjGradOffset**(sampler1DShadow *sampler*, vec4 *P*, float *dPdx*, float *dPdy*, int *offset*)
float **textureProjGradOffset**(sampler2DShadow *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*, vec2 *offset*)

Texture Gather Instructions [8.9.3]

Texture gather operation.

gvec4 **textureGather**(gsampler2D *sampler*, vec2 *P* [, int *comp*])
gvec4 **textureGather**(gsampler2DArray *sampler*, vec3 *P* [, int *comp*])
gvec4 **textureGather**(gsamplerCube *sampler*, vec3 *P* [, int *comp*])
gvec4 **textureGather**(gsamplerCubeArray *sampler*, vec4 *P*[, int *comp*])
gvec4 **textureGather**(gsampler2DRect *sampler*, vec3 *P* [, int *comp*])
vec4 **textureGather**(sampler2DShadow *sampler*, vec2 *P*, float *refZ*)
vec4 **textureGather**(sampler2DArrayShadow *sampler*, vec3 *P*, float *refZ*)
vec4 **textureGather**(samplerCubeShadow *sampler*, vec3 *P*, float *refZ*)
vec4 **textureGather**(samplerCubeArrayShadow *sampler*, vec4 *P*, float *refZ*)
vec4 **textureGather**(sampler2DRectShadow *sampler*, vec2 *P*, float *refZ*)

Texture gather as in **textureGather** by offset as described in **textureOffset** except minimum and maximum offset values are given by {MIN, MAX}_PROGRAM_TEXTURE_GATHER_OFFSET.

gvec4 **textureGatherOffset**(gsampler2D *sampler*, vec2 *P*, ivec2 *offset* [, int *comp*])
gvec4 **textureGatherOffset**(gsampler2DArray *sampler*, vec3 *P*, ivec2 *offset* [, int comp])
gvec4 **textureGatherOffset**(gsampler2DRect *sampler*, vec3 *P*, ivec2 *offset* [, int comp])
vec4 **textureGatherOffset**(sampler2DShadow *sampler*, vec2 *P*, float *refZ*, ivec2 *offset*)
vec4 **textureGatherOffset**(sampler2DArrayShadow *sampler*, vec3 *P*, float *refZ*, ivec2 *offset*)
vec4 **textureGatherOffset**(sampler2DRectShadow *sampler*, vec2 *P*, float *refZ*, ivec2 *offset*)

Texture gather as in **textureGatherOffset** except that *offsets* is used to determine the location of the four texels to sample.

gvec4 **textureGatherOffsets**(gsampler2D *sampler*, vec2 *P*, ivec2 *offset*[4] [, int *comp*])
gvec4 **textureGatherOffsets**(gsampler2DArray *sampler*, vec3 *P*, ivec2 *offset*[4] [, int *comp*])
gvec4 **textureGatherOffsets**(gsampler2DRect *sampler*, vec3 *P*, ivec2 *offset*[4][, int *comp*])
vec4 **textureGatherOffsets**(sampler2DShadow *sampler*, vec2 *P*, float *refZ*, ivec2 *offset*[4])
vec4 **textureGatherOffsets**(sampler2DArrayShadow *sampler*, vec3 *P*, float *refZ*, ivec2 *offset*[4])
vec4 **textureGatherOffsets**(sampler2DRectShadow *sampler*, vec2 *P*, float *refZ*, ivec2 *offset*[4])