WebGL™ is an immediate-mode 3D rendering API designed for the web. It is derived from OpenGL® ES 3.0, and provides similar rendering functionality, but in an HTML context. WebGL 2 is not entirely backwards compatible with WebGL 1. Existing error-free content written against the core WebGL 1 specification without extensions will often run in WebGL 2 without modification, but this is not always the case.

The WebGL 2 specification shows differences from the WebGL 1 specification. Both WebGL specifications are available at khronos.org/webgl. Unless otherwise specified, the behavior of each method is defined by the OpenGL ES 3.0 specification. The OpenGL ES specification is at khronos.org/opengles.

- **[n.n.n]** refers to sections in the WebGL 1.0 specification.
- **[n.n.n]** refers to sections in the WebGL 2.0 specification.
- **Content in blue** is newly added with WebGL 2.0.
- **Content in purple** or marked with • has no corresponding OpenGL ES 3.0 function.

Interfaces

WebGLContextAttributes [5.2]

This interface contains requested drawing surface attributes and is passed as the second parameter to **getContext**. Some of these are optional requests and may be ignored by an implementation.

alpha Default: true
If true, requests a drawing buffer with an alpha channel for the purposes of performing OpenGL destination alpha operations and compositing with the page.

depth Default: true
If true, requests drawing buffer with a depth buffer of at least 16 bits. Must obey.

stencil Default: false
If true, requests a stencil buffer of at least 8 bits. Must obey.

antialias Default: true
If true, requests drawing buffer with antialiasing using its choice of technique (multisample/supersample) and quality. Must obey.

premultipliedAlpha Default: true
If true, requests drawing buffer which contains colors with premultiplied alpha. (Ignored if alpha is false.)

preserveDrawingBuffer Default: false
If true, requests that contents of the drawing buffer remain in between frames, at potential performance cost. May have significant performance implications on some hardware.

preferLowPowerToHighPerformance Default: false
Provides a hint suggesting that implementation create a context that optimizes for power consumption over performance.

failIfMajorPerformanceCaveat Default: false
If true, context creation will fail if the performance of the created WebGL context would be dramatically lower than that of a native application making equivalent OpenGL calls.

WebGLObject [5.3]

This is the parent interface for all WebGL resource objects:

WebGLBuffer [5.4]	Created as if by **glGenBuffers,** bound by **glBindBuffer,** destroyed by **glDeleteBuffers** in OpenGL ES
WebGLFramebuffer [5.5]	Created as if by **glGenFramebuffers,** bound by **glBindFramebuffer,** destroyed by **glDeleteFramebuffers** in OpenGL ES
WebGLProgram [5.6]	Created as if by **glCreateProgram,** used by **glUseProgram,** destroyed by **glDeleteProgram** in OpenGL ES
WebGLRenderbuffer [5.7]	Created as if by **glGenRenderbuffers,** bound by **glBindRenderbuffer,** destroyed by **glDeleteRenderbuffers** in OpenGL ES
WebGLShader [5.8]	Created as if by **glCreateShader,** attached to program by **glAttachShader,** destroyed by **glDeleteShader** in OpenGL ES
WebGLTexture [5.9]	Created as if by **glGenTextures,** bound by **glBindTexture,** destroyed by **glDeleteTextures** in OpenGL ES
WebGLUniformLocation [5.10]	Location of a uniform variable in a shader program.
WebGLActiveInfo [5.11]	Information returned from calls to **getActiveAttrib** and **getActiveUniform**. The read-only attributes are: int *size* enum *type* DOMstring *name*
WebGLShaderPrecision-Format [5.12]	Information returned from calls to **getShaderPrecisionFormat**. The read-only attributes are: int *rangeMin* int *rangeMax* int *precision*
WebGLQuery [3.2]	Created as if by **glGenQueries,** made active by **glBeginQuery,** concluded by **glEndQuery,** destroyed by **glDeleteQueries** in OpenGL ES
WebGLSampler [3.3]	Created as if by **glGenSamplers,** bound by **glBindSampler,** destroyed by **glDeleteSamplers** in OpenGL ES
WebGLSync [3.4]	Created as if by **glFenceSync,** blocked on by **glClientWaitSync,** waited on internal GL by **glWaitSync,** queried by **glGetSynciv,** destroyed by **glDeleteSync** in OpenGL ES
WebGLTransformFeedback [3.5]	Created as if by **glGenTransformFeedbacks,** bound by **glBindTransformFeedback,** destroyed by **glDeleteTransformFeedbacks** in OpenGL ES
WebGLVertexArrayObject [3.6]	Created as if by **glGenVertexArrays,** bound by **glBindVertexArray,** destroyed by **glDeleteVertexArrays** in OpenGL ES

WebGL Context Creation [2.1]

To use WebGL, the author must obtain a WebGL rendering context for a given HTMLCanvasElement. This context manages the OpenGL state and renders to the drawing buffer.

[canvas].**getContext**(
"webgl", WebGLContextAttributes? *optionalAttribs*)
Returns a WebGL 1.0 rendering context

[canvas].**getContext**(
"webgl2", WebGLContextAttributes? *optionalAttribs*)
Returns a WebGL 2.0 rendering context

Per-Fragment Operations [5.14.3]

void **blendColor**(clampf *red*, clampf *green*, clampf *blue*, clampf *alpha*);

void **blendEquation**(enum *mode*);
mode: See *modeRGB* for **blendEquationSeparate**

void **blendEquationSeparate**(enum *modeRGB*, enum *modeAlpha*);
modeRGB, and *modeAlpha*: FUNC_ADD, FUNC_SUBTRACT, FUNC_REVERSE_SUBTRACT

void **blendFunc**(enum *sfactor*, enum *dfactor*);
sfactor: Same as for *dfactor*, plus SRC_ALPHA_SATURATE
dfactor: ZERO, ONE, [ONE_MINUS_]SRC_COLOR, [ONE_MINUS_]DST_COLOR, [ONE_MINUS_]SRC_ALPHA, [ONE_MINUS_]DST_ALPHA, [ONE_MINUS_]CONSTANT_COLOR, [ONE_MINUS_]CONSTANT_ALPHA
sfactor and *dfactor* may not both reference constant color

void **blendFuncSeparate**(enum *srcRGB*, enum *dstRGB*, enum *srcAlpha*, enum *dstAlpha*);
srcRGB, srcAlpha: See *sfactor* for **blendFunc**
dstRGB, dstAlpha: See *dfactor* for **blendFunc**

void **depthFunc**(enum *func*);
func: NEVER, ALWAYS, LESS, [NOT]EQUAL, {GE, LE}QUAL, GREATER

void **sampleCoverage**(float *value*, bool *invert*);

void **stencilFunc**(enum *func*, int *ref*, uint *mask*);
func: NEVER, ALWAYS, LESS, LEQUAL, [NOT]EQUAL, GREATER, GEQUAL

void **stencilFuncSeparate**(enum *face*, enum *func*, int *ref*, uint *mask*);
face: FRONT, BACK, FRONT_AND_BACK
func: NEVER, ALWAYS, LESS, LEQUAL, [NOT]EQUAL, GREATER, GEQUAL

void **stencilOp**(enum *fail*, enum *zfail*, enum *zpass*);
fail, zfail, and *zpass*: KEEP, ZERO, REPLACE, INCR, DECR, INVERT, INCR_WRAP, DECR_WRAP

void **stencilOpSeparate**(enum *face*, enum *fail*, enum *zfail*, enum *zpass*);
face: FRONT, BACK, FRONT_AND_BACK
fail, zfail, and *zpass*: See *fail, zfail,* and *zpass* for **stencilOp**

ArrayBuffer and Typed Arrays [5.13]

Data is transferred to WebGL using ArrayBuffer and views. Buffers represent unstructured binary data, which can be modified using one or more typed array views. Consult the ECMAScript specification for more details on Typed Arrays.

Buffers

ArrayBuffer(ulong *byteLength*);
byteLength: read-only, length of view in bytes.
Creates a new buffer. To modify the data, create one or more views referencing it.

Views

In the following, *ViewType* may be Int8Array, Int16Array, Int32Array, Uint8Array, Uint16Array, Uint32Array, Float32Array.

ViewType(ulong *length*);
Creates a view and a new underlying buffer.
length: Read-only, number of elements in this view.

ViewType(*ViewType other*);
Creates new underlying buffer and copies *other* array.

ViewType(type[] *other*);
Creates new underlying buffer and copies *other* array.

ViewType(ArrayBuffer *buffer*, [optional] ulong *byteOffset*, [optional] ulong *length*);
Create a new view of given buffer, starting at optional byte offset, extending for optional length elements.
buffer: Read-only, buffer backing this view
byteOffset: Read-only, byte offset of view start in buffer
length: Read-only, number of elements in this view

Other Properties

byteLength: Read-only, length of view in bytes.
const ulong *BYTES_PER_ELEMENT*: element size in bytes.

Methods

view[*i*] = get/set element *i*

set(*ViewType other*[, ulong *offset*]);

set(type[] *other*[, ulong *offset*]);
Replace elements in this view with those from *other*, starting at optional *offset*.

ViewType **subArray**(long *begin*[, long *end*]);
Return a subset of this view, referencing the same underlying buffer.

Buffer Objects [5.14.5] [3.7.3]

Once bound, buffers may not be rebound with a different target.

void **bindBuffer**(enum *target*, WebGLBuffer? *buffer*);
target: ARRAY_BUFFER, ELEMENT_ARRAY_BUFFER, PIXEL_[UN]PACK_BUFFER, COPY_{READ, WRITE}_BUFFER, TRANSFORM_FEEDBACK_BUFFER, UNIFORM_BUFFER

typedef (ArrayBuffer or ArrayBufferView) BufferDataSource

void **bufferData**(enum *target*, long *size*, enum *usage*);
target: See *target* for **bindBuffer**
usage: STREAM_{DRAW, READ, COPY}, STATIC_{DRAW, READ, COPY}, DYNAMIC_{DRAW, READ, COPY}

void **bufferData**(enum *target*, ArrayBufferView *srcData*, enum *usage*, uint *srcOffset*[, uint *length*=0]);
target and *usage:* Same as for **bufferData** above

void **bufferData**(enum *target*, BufferDataSource *data*, enum *usage*);
target and *usage:* Same as for **bufferData** above

void **bufferSubData**(enum *target*, long *offset*, BufferDataSource *data*);
target: See *target* for **bindBuffer**

void **bufferSubData**(enum *target*, intptr *dstByteOffset*, ArrayBufferView *srcData*, uint *srcOffset*[, uint *length*=0]);
target: See *target* for **bindBuffer**

void **copyBufferSubData**(enum *readTarget*, enum *writeTarget*, intptr *readOffset*, intptr *writeOffset*, sizeiptr *size*);

• void **getBufferSubData**(enum *target*, intptr *srcByteOffset*, ArrayBufferView *dstBuffer*[, uint *dstOffset*=0[, uint *length*=0]]);

Buffer Objects (continued)

Object **createBuffer**();
Corresponding OpenGL ES function is **GenBuffers**

void **deleteBuffer**(WebGLBuffer? *buffer*);

any **getBufferParameter**(enum *target*, enum *pname*);
target: See *target* for **bindBuffer**
pname: BUFFER_SIZE, BUFFER_USAGE

bool **isBuffer**(WebGLBuffer? *buffer*);

Detect and Enable Extensions [5.14]

- string[ ] **getSupportedExtensions**();
- object **getExtension**(string *name*);

Available in the **WebGLRenderingContext** interface.

Get information about the context

- contextStruct **getContextAttributes**();

Set and get state

Calls in this group behave identically to their OpenGL ES counterparts unless otherwise noted. Source and destination factors may not both reference constant color.

Programs and Shaders [5.14.9] [3.7.7]

Shaders are loaded with a source string (**shaderSource**), compiled (**compileShader**), attached to a program (**attachShader**), linked (**linkProgram**), then used (**useProgram**).

[WebGLHandlesContextLoss] int **getFragDataLocation**(WebGLProgram *program*, DOMString *name*);

void **attachShader**(Object *program*, Object *shader*);

void **bindAttribLocation**(Object *program*, uint *index*, string *name*);

void **compileShader**(Object *shader*);

Object **createProgram**();

Object **createShader**(enum *type*);
type: VERTEX_SHADER, FRAGMENT_SHADER

void **deleteProgram**(Object *program*);

void **deleteShader**(Object *shader*);

void **detachShader**(Object *program*, Object *shader*);

Object[ ] **getAttachedShaders**(Object *program*);

any **getProgramParameter**(WebGLProgram? *program*, enum *pname*);
Corresponding OpenGL ES function is **GetProgramiv**
pname: DELETE_STATUS, LINK_STATUS, VALIDATE_STATUS, ATTACHED_SHADERS, ACTIVE_{ATTRIBUTES, UNIFORMS}, ACTIVE_UNIFORM_BLOCKS , TRANSFORM_FEEDBACK_BUFFER_MODE, TRANSFORM_FEEDBACK_VARYINGS

string **getProgramInfoLog**(Object *program*);

any **getShaderParameter**(Object *shader*, enum *pname*);
Corresponding OpenGL ES function is **GetShaderiv**
pname: SHADER_TYPE, DELETE_STATUS, COMPILE_STATUS

string **getShaderInfoLog**(Object *shader*);

string **getShaderSource**(Object *shader*);

bool **isProgram**(Object *program*);

bool **isShader**(Object *shader*);

void **linkProgram**(Object *program*);

void **shaderSource**(Object *shader*, string *source*);

void **useProgram**(Object *program*);

void **validateProgram**(Object *program*);

Uniforms and Attributes [5.14.10] [3.7.8]

Values used by the shaders are passed in as a uniform of vertex attributes.

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

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

WebGLActiveInfo? **getActiveAttrib**(WebGLProgram *program*, uint *index*);

WebGLActiveInfo? **getActiveUniform**(WebGLProgram *program*, uint *index*);

int **getAttribLocation**(WebGLProgram *program*, string *name*);

any **getUniform**(WebGLProgram? *program*, uint *location*);

WebGLUniformLocation? **getUniformLocation**(Object *program*, string *name*);

any **getVertexAttrib**(uint *index*, enum *pname*);
pname: CURRENT_VERTEX_ATTRIB , VERTEX_ATTRIB_ARRAY_{BUFFER_BINDING, ENABLED}, VERTEX_ATTRIB_ARRAY_{NORMALIZED, SIZE, STRIDE, TYPE}, VERTEX_ATTRIB_ARRAY_{INTEGER, DIVISOR}

long **getVertexAttribOffset**(uint *index*, enum *pname*);
Corresponding OpenGL ES function is **GetVertexAttribPointerv**
pname: VERTEX_ATTRIB_ARRAY_POINTER

void **uniform[1234]fv**(WebGLUniformLocation? *location*, Float32List *data*[, uint *srcOffset*=0[, uint *srcLength*=0]]);

void **uniform[1234]iv**(WebGLUniformLocation? *location*, Int32List *data*[, uint *srcOffset*=0[, uint *srcLength*=0]]);

void uniform[1234]uiv(WebGLUniformLocation? *location*, Uint32List *data*[, uint *srcOffset*=0[, uint *srcLength*=0]]);

void uniformMatrix[234]fv(WebGLUniformLocation? *location*, bool *transpose*, Float32List *data*[, uint *srcOffset*=0[, uint *srcLength*=0]]);

void uniformMatrix[234]x[234]fv(WebGLUniformLocation? *location*, bool *transpose*, Float32List *data*[, uint *srcOffset*=0[, uint *srcLength*=0]]);

void **vertexAttrib[1234]f**(uint *index*, ...);

void **vertexAttrib[1234]fv**(uint *index*, Array *value*);

void **vertexAttribI4[u]i[v]**(uint *index*, ...);

void **vertexAttribPointer**(uint *index*, int *size*, enum *type*, bool *normalized*, long *stride*, long *offset*);
type: BYTE, SHORT, UNSIGNED_{BYTE, SHORT}, FIXED, FLOAT
index: [0, MAX_VERTEX_ATTRIBS - 1]
stride: [0, 255]
offset, stride: must be a multiple of the type size in WebGL

void **vertexAttribIPointer**(uint *index*, int *size*, enum *type*, sizei *stride*, intptr *offset*);

Special Functions [5.13.3] [3.7.2]

- contextStruct **getContextAttributes**() [5.13.2]

void **disable**(enum *cap*);
cap: BLEND, CULL_FACE, DEPTH_TEST, DITHER, POLYGON_OFFSET_FILL, SAMPLE_ALPHA_TO_COVERAGE, SAMPLE_COVERAGE, SCISSOR_TEST, STENCIL_TEST

void **enable**(enum *cap*);
cap: See *cap* for **disable**

void **finish**(); [5.13.11]

void **flush**(); [5.13.11]

enum **getError**();
Returns: OUT_OF_MEMORY, INVALID_{ENUM, OPERATION, FRAMEBUFFER_OPERATION, VALUE}, NO_ERROR, CONTEXT_LOST_WEBGL

any **getParameter**(enum *pname*);
pname: {ALPHA, RED, GREEN, BLUE, SUBPIXEL}_BITS, ACTIVE_TEXTURE, ALIASED_{LINE_WIDTH, POINT_SIZE}_RANGE, ARRAY_BUFFER_BINDING, BLEND_DST_{ALPHA, RGB}, BLEND_EQUATION_{ALPHA, RGB}, BLEND_SRC_{ALPHA, RGB}, BLEND[_COLOR], COLOR_{CLEAR_VALUE, WRITEMASK}, COPY_{READ, WRITE}_BUFFER_BINDING, [NUM_]COMPRESSED_TEXTURE_FORMATS, CULL_FACE[_MODE], CURRENT_PROGRAM, DEPTH_{BITS, CLEAR_VALUE, FUNC}, DEPTH_{RANGE, TEST, WRITEMASK}, DRAW_BUFFERi, DRAW_FRAMEBUFFER_BINDING, ELEMENT_ARRAY_BUFFER_BINDING, DITHER, FRAMEBUFFER_BINDING, FRONT_FACE, FRAGMENT_SHADER_DERIVATIVE_HINT, GENERATE_MIPMAP_HINT, LINE_WIDTH, MAX_3D_TEXTURE_SIZE, MAX_ARRAY_TEXTURE_LAYERS, MAX_CLIENT_WAIT_TIMEOUT_WEBGL, MAX_COLOR_ATTACHMENTS, MAX_COMBINED_FRAGMENT_UNIFORM_COMPONENTS, MAX_[COMBINED_]TEXTURE_IMAGE_UNITS, MAX_COMBINED_UNIFORM_BLOCKS, MAX_COMBINED_VERTEX_UNIFORM_COMPONENTS, MAX_DRAW_BUFFERS, MAX_ELEMENT_INDEX, MAX_ELEMENTS_{INDICES, VERTICES}, MAX_FRAGMENT_INPUT_COMPONENTS, MAX_FRAGMENT_UNIFORM_{BLOCKS, COMPONENTS}, MAX_PROGRAM_TEXEL_OFFSET, MAX_SAMPLES, MAX_SERVER_WAIT_TIMEOUT, MAX_TEXTURE_LOD_BIAS, MAX_TRANSFORM_FEEDBACK_INTERLEAVED_COMPONENTS, MAX_TRANSFORM_FEEDBACK_SEPARATE_COMPONENTS, MAX_TRANSFORM_FEEDBACK_SEPARATE_ATTRIBS, MAX_UNIFORM_BLOCK_SIZE, MAX_UNIFORM_BUFFER_BINDINGS, MAX_{CUBE_MAP_TEXTURE, RENDERBUFFER, TEXTURE}_SIZE, MAX_VARYING_{COMPONENTS, VECTORS}, MAX_VERTEX_{ATTRIBS, TEXTURE_IMAGE_UNITS}, MAX_VERTEX_UNIFORM_{BLOCKS, COMPONENTS, VECTORS}, MAX_VIEWPORT_DIMS, PACK_ALIGNMENT, MIN_PROGRAM_TEXEL_OFFSET, PACK_ROW_LENGTH, PACK_SKIP_{PIXELS, ROWS}, PIXEL_[UN]PACK_BUFFER_BINDING, POLYGON_OFFSET_{FACTOR, FILL, UNITS}, RASTERIZER_DISCARD, READ_{BUFFER, FRAMEBUFFER_BINDING}, RENDERBUFFER_BINDING, RENDERER, SAMPLE_BUFFERS, SAMPLE_[ALPHA_TO_]COVERAGE, SAMPLE_COVERAGE_{INVERT, VALUE}, SAMPLES, SCISSOR_{BOX, TEST}, SHADING_LANGUAGE_VERSION, STENCIL_{BITS, CLEAR_VALUE, TEST}, STENCIL_[BACK_]{FAIL, FUNC, REF, VALUE_MASK, WRITEMASK}, STENCIL_[BACK_]PASS_DEPTH_{FAIL, PASS}, TEXTURE_BINDING_{2D, CUBE_MAP, 3D, 2D_ARRAY}, TRANSFORM_FEEDBACK_{ACTIVE, BINDING, BUFFER_BINDING}, TRANSFORM_FEEDBACK_PAUSED, UNIFORM_BUFFER_BINDING, UNIFORM_BUFFER_OFFSET_ALIGNMENT, UNPACK_ALIGNMENT, UNPACK_{COLORSPACE_CONVERSION_WEBGL, FLIP_Y_WEBGL, PREMULTIPLY_ALPHA_WEBGL}, UNPACK_IMAGE_HEIGHT, UNPACK_ROW_LENGTH, UNPACK_SKIP_{IMAGES, PIXELS, ROWS}, VENDOR, VERSION, VIEWPORT, VERTEX_ARRAY_BINDING

any **getIndexedParameter**(enum *target*, uint *index*);
target: TRANSFORM_FEEDBACK_BUFFER_{BINDING, SIZE, START}, UNIFORM_BUFFER_{BINDING, SIZE, START}

void **hint**(enum *target*, enum *mode*);
target: GENERATE_MIPMAP_HINT
hint: FASTEST, NICEST, DONT_CARE

bool **isEnabled**(enum *cap*);
cap: RASTERIZER_DISCARD Also see *cap* for **disable**

void **pixelStorei**(enum *pname*, int *param*);
pname: PACK_ALIGNMENT, PACK_ROW_LENGTH, PACK_SKIP_{PIXELS, ROWS}, UNPACK_ALIGNMENT, UNPACK_COLORSPACE_CONVERSION_WEBGL, UNPACK_{FLIP_Y_WEBGL, PREMULTIPLY_ALPHA_WEBGL}, UNPACK_IMAGE_HEIGHT, UNPACK_ROW_LENGTH, UNPACK_SKIP_{PIXELS, ROWS, IMAGES}

Rasterization [5.13.3]

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

void **frontFace**(enum *mode*);
mode: CCW, CW

void **lineWidth**(float *width*);

void **polygonOffset**(float *factor*, float *units*);

View and Clip [5.13.3 - 5.13.4]

The viewport specifies the affine transformation of x and y from normalized device coordinates to window coordinates. Drawing buffer size is determined by the HTMLCanvasElement.

void **depthRange**(float *zNear*, float *zFar*);
zNear: Clamped to the range 0 to 1 Must be <= *zFar*
zFar: Clamped to the range 0 to 1.

void **scissor**(int *x*, int *y*, long *width*, long *height*);

void **viewport**(int *x*, int *y*, long *width*, long *height*);

Detect context lost events [5.13.13]

bool **isContextLost**();

Writing to the Draw Buffer [5.14.11] [3.7.9]

When rendering is directed to drawing buffer, OpenGL ES rendering calls cause the drawing buffer to be presented to the HTML page compositor at start of next compositing operation.

void **drawArrays**(enum *mode*, int *first*, sizei *count*);
mode: POINTS, LINE_STRIP, LINE_LOOP, LINES, TRIANGLE_STRIP, TRIANGLE_FAN, TRIANGLES
first: May not be a negative value.

void **drawElements**(enum *mode*, sizei *count*, enum *type*, intptr *offset*);
mode: POINTS, LINE_STRIP, LINE_LOOP, LINES, TRIANGLE_STRIP, TRIANGLE_FAN, TRIANGLES
type: UNSIGNED_BYTE, UNSIGNED_SHORT

void **clear**(bitfield *mask*);

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

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

void **drawElementsInstanced**(enum *mode*, sizei *count*, enum *type*, intptr *offset*, sizei *instanceCount*);

void **drawRangeElements**(enum *mode*, uint *start*, uint *end*, sizei *count*, enum *type*, intptr *offset*);

Vertex Array Objects [3.7.17]

VAOs encapsulate all state related to the definition of data used by the vertex processor.

void **bindVertexArray**(
WebGLVertexArrayObject? *vertexArray*);

WebGLVertexArrayObject? **createVertexArray**();

void **deleteVertexArray**(
WebGLVertexArrayObject? *vertexArray*);

[WebGLHandlesContextLoss] boolean **isVertexArray**(
WebGLVertexArrayObject? *vertexArray*);

Read Back Pixels [5.14.12] [3.7.10]

Read pixels in current framebuffer into ArrayBufferView object.

void **readPixels**(int *x*, int *y*, long *width*, long *height*, enum *format*, enum *type*, ArrayBufferView *pixels*);
format: RGBA
type: UNSIGNED_BYTE

void **readPixels**(int *x*, int *y*, sizei *width*, sizei *height*, enum *format*, enum *type*, ArrayBufferView *dstData*, uint *dstOffset*);

void **readPixels**(int *x*, int *y*, sizei *width*, sizei *height*, enum *format*, enum *type*, intptr *offset*);

Framebuffer Objects [5.14.6] [3.7.4]

Framebuffer objects provide an alternative rendering target to the drawing buffer.

void **bindFramebuffer**(enum *target*, WebGLFramebuffer? *framebuffer*);
target: [READ_, DRAW_]FRAMEBUFFER

[WebGLHandlesContextLoss] enum **checkFramebufferStatus**(enum *target*);
target: [READ_, DRAW_]FRAMEBUFFER
Returns: FRAMEBUFFER_{COMPLETE, UNSUPPORTED}, FRAMEBUFFER_INCOMPLETE_{ATTACHMENT, DIMENSIONS, MULTISAMPLE, MISSING_ATTACHMENT}, FRAMEBUFFER_UNDEFINED

Object **createFramebuffer**();
Corresponding OpenGL ES function is **GenFramebuffers**

void **deleteFramebuffer**(Object *buffer*);

void **framebufferRenderbuffer**(enum *target*, enum *attachment*, enum *renderbuffertarget*, WebGLRenderbuffer *renderbuffer*);
target: FRAMEBUFFER
attachment: COLOR_ATTACHMENT0, COLOR_ATTACHMENT*n* where *n* may be an integer from 1 to 15, {DEPTH, STENCIL, DEPTH_STENCIL}_ATTACHMENT
renderbuffertarget: RENDERBUFFER

bool **isFramebuffer**(WebGLFramebuffer *framebuffer*);

void **framebufferTexture2D**(enum *target*, enum *attachment*, enum *textarget*, WebGLTexture *texture*, int *level*);
target and *attachment*: Same as for **framebufferRenderbuffer**
textarget: TEXTURE_2D, TEXTURE_CUBE_MAP_POSITIVE{X, Y, Z}, TEXTURE_CUBE_MAP_NEGATIVE{X, Y, Z},

any **getFramebufferAttachmentParameter**(enum *target*, enum *attachment*, enum *pname*);
target and *attachment*: Same as for **framebufferRenderbuffer**
pname: FRAMEBUFFER_ATTACHMENT_OBJECT_{TYPE, NAME}, FRAMEBUFFER_ATTACHMENT_TEXTURE_LEVEL, FRAMEBUFFER_ATTACHMENT_TEXTURE_CUBE_MAP_FACE, FRAMEBUFFER_ATTACHMENT_{ALPHA, BLUE, GREEN, RED}_SIZE, FRAMEBUFFER_ATTACHMENT_COLOR_ENCODING, FRAMEBUFFER_ATTACHMENT_COMPONENT_TYPE, FRAMEBUFFER_ATTACHMENT_{DEPTH, STENCIL}_SIZE, FRAMEBUFFER_ATTACHMENT_TEXTURE_LAYER

void **blitFramebuffer**(int *srcX0*, int *srcY0*, int *srcX1*, int *srcY1*, int *dstX0*, int *dstY0*, int *dstX1*, int *dstY1*, bitfield *mask*, enum *filter*);

void **framebufferTextureLayer**(enum *target*, enum *attachment*, WebGLTexture? *texture*, int *level*, int *layer*);

void **invalidateFramebuffer**(enum *target*, sequence<enum> *attachments*);

void **invalidateSubFramebuffer** (enum *target*, sequence<enum> *attachments*, int *x*, int *y*, sizei *width*, sizei *height*);

void **readBuffer**(enum *src*);

Renderbuffer Objects [5.14.7] [3.7.5]

Renderbuffer objects are used to provide storage for the individual buffers used in a framebuffer object.

void **bindRenderbuffer**(enum *target*, Object *renderbuffer*);
target: RENDERBUFFER

Object **createRenderbuffer**();
Corresponding OpenGL ES function is **GenRenderbuffers**

void **deleteRenderbuffer**(Object *renderbuffer*);

any **getRenderbufferParameter**(enum *target*, enum *pname*);
target: RENDERBUFFER
pname: RENDERBUFFER_{WIDTH, HEIGHT, INTERNAL_FORMAT}, REDEDRBUFFER_{RED, GREEN, BLUE, ALPHA, DEPTH}_SIZE, RENDERBUFFER_STENCIL_SIZE, RENDERBUFFER_SAMPLES

any **getInternalformatParameter**(enum *target*, enum *internalformat*, enum *pname*);
pname: SAMPLES

bool **isRenderbuffer**(Object *renderbuffer*);

void **renderbufferStorage**(enum *target*, enum *internalformat*, sizei *width*, sizei *height*);
target: RENDERBUFFER
internalformat: Accepts internal formats from OpenGL ES 3.0, as well as DEPTH_STENCIL

void **renderbufferStorageMultisample**(enum *target*, enum *internalformat*, sizei *width*, sizei *height*);

Texture Objects [5.14.8] [3.7.6]

Texture objects provide storage and state for texturing operations. WebGL adds an error for operations relating to the currently bound texture if no texture is bound.

void **activeTexture**(enum *texture*) [5.14.3]
texture: [TEXTURE0..TEXTURE*i*] where *i* = MAX_COMBINED_TEXTURE_IMAGE_UNITS - 1

void bindTexture(enum *target*, WebGLTexture? *texture*);
target: TEXTURE_{2D, 3D, 2D_ARRAY}, TEXTURE_CUBE_MAP

void **copyTexImage2D**(enum *target*, int *level*, enum *internalformat*, int *x*, int *y*, long *width*, long *height*, int *border*);
target: TEXTURE_2D, TEXTURE_CUBE_MAP_POSITIVE_{X,Y,Z} TEXTURE_CUBE_MAP_NEGATIVE_{X,Y,Z}, TEXTURE_3D, TEXTURE_2D_ARRAY
internalformat: See Tables 3.12, 3.13, 3.14 in the OpenGL ES 3 specification

void **copyTexSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *x*, int *y*, long *width*, long *height*);
target: See *target* for **copyTexImage2D**

Object **createTexture**();
Corresponding OpenGL ES function is **GenTextures**

void **deleteTexture**(Object *texture*);

void **generateMipmap**(enum *target*);
target: see *target* for **bindTexture**

any **getTexParameter**(enum *target*, enum *pname*);
target: TEXTURE_2D, TEXTURE_CUBE_MAP
pname: TEXTURE_BASE_LEVEL, TEXTURE_COMPARE_{FUNC, MODE}, TEXTURE_IMMUTABLE_{FORMAT, LEVELS}, TEXTURE_MAX_{LEVEL, LOD}, TEXTURE_MIN_LOD, TEXTURE_{MIN, MAG}_FILTER, TEXTURE_WRAP_{R, S, T}

bool **isTexture**(Object *texture*);

void **texImage2D**(enum *target*, int *level*, enum *internalformat*, long *width*, long *height*, int *border*, enum *format*, enum *type*, ArrayBufferView? *pixels*);

The following values apply to all variations of **texImage2D**.

target: See *target* for **copyTexImage2D**
source: pixels of type ImageData, image of type HTMLImageElement, canvas of type HTMLCanvasElement, video of type HTMLVideoElement

void **texImage2D**(enum *target*, int *level*, int *internalformat*, sizei *width*, sizei *height*, int *border*, enum *format*, enum *type*, ArrayBufferView *srcData*, uint *srcOffset*);

[throws] void **texImage2D**(enum *target*, int *level*, int *internalformat*, sizei *width*, sizei *height*, int *border*, enum *format*, enum *type*, TexImageSource *source*);

void **texImage2D**(enum *target*, int *level*, int *internalformat*, sizei *width*, sizei *height*, int *border*, enum *format*, enum *type*, intptr *offset*);

void **texParameterf**(enum *target*, enum *pname*, float *param*);
target: TEXTURE_2D, TEXTURE_CUBE_MAP
pname: TEXTURE_BASE_LEVEL, TEXTURE_COMPARE_{FUNC, MODE}, TEXTURE_MAX_{LEVEL, LOD}, TEXTURE_{MIN, MAG}_FILTER, TEXTURE_MIN_LOD, TEXTURE_WRAP_{R, S, T}

void **texParameteri**(enum *target*, enum *pname*, int *param*);
target: TEXTURE_2D, TEXTURE_CUBE_MAP
pname: See *pname* for **getTexParameter**

void **texSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, long *width*, long *height*, enum *format*, enum *type*, ArrayBufferView? *pixels*);

Following values apply to all variations of **texSubImage2D**.

target: See *target* for **copyTexImage2D**
format and *type:* See *format* and *type* for **texImage2D**
object: See *object* for **texImage2D**

texStorage2D may have lower memory costs than **texImage2D** in some implementations and should be considered a preferred alternative to **texImage2D**.

void **texSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, sizei *width*, sizei *height*, enum *format*, enum *type*, ArrayBufferView *srcData*, uint *srcOffset*);

void **texSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, sizei *width*, sizei *height*, enum *format*, enum *type*, TexImageSource *source*);

void **texSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, sizei *width*, sizei *height*, enum *format*, enum *type*, intptr *offset*);

void **texStorage2D**(enum *target*, sizei *levels*, enum *internalformat*, sizei *width*, sizei *height*);

void **texStorage3D**(enum *target*, sizei *levels*, enum *internalformat*, sizei *width*, sizei *height*, sizei *depth*);

texStorage3D may have lower memory costs than **texImage3D** in some implementations and should be considered a preferred alternative to allocate three-dimensional textures.

void **texImage3D**(enum *target*, int *level*, int *internalformat*, sizei *width*, sizei *height*, sizei *depth*, int *border*, enum *format*, enum *type*, ArrayBufferView? *srcData*);

void **texImage3D**(enum *target*, int *level*, int *internalformat*, sizei *width*, sizei *height*, sizei *depth*, int *border*, enum *format*, enum *type*, ArrayBufferView *srcData*, uint *srcOffset*);

void **texImage3D**(enum *target*, int *level*, int *internalformat*, sizei *width*, sizei *height*, sizei *depth*, int *border*, enum *format*, enum *type*, TexImageSource *source*);

void **texImage3D**(enum *target*, int *level*, int *internalformat*, sizei *width*, sizei *height*, sizei *depth*, int *border*, enum *format*, enum *type*, intptr *offset*);

void **texSubImage3D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *zoffset*, sizei *width*, sizei *height*, sizei *depth*, enum *format*, enum *type*, ArrayBufferView? *srcData* [, uint *srcOffset*=0]);

void **texSubImage3D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *zoffset*, sizei *width*, sizei *height*, sizei *depth*, enum *format*, enum *type*, TexImageSource *source*);

void **texSubImage3D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *zoffset*, sizei *width*, sizei *height*, sizei *depth*, enum *format*, enum *type*, intptr *offset*);

void **copyTexSubImage3D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *zoffset*, int *x*, int *y*, sizei *width*, sizei *height*);

void **compressedTexImage2D**(enum *target*, int *level*, enum *internalformat*, sizei *width*, sizei *height*, int *border*, ArrayBufferView *srcData*[, uint *srcOffset*=0[, uint *srcLengthOverride*=0]]);

void **compressedTexSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, sizei *width*, sizei *height*, enum *format*, ArrayBufferView *srcData*[, uint *srcOffset*=0[, uint *srcLengthOverride*=0]]);

void **compressedTexImage3D**(enum *target*, int *level*, enum *internalformat*, sizei *width*, sizei *height*, sizei *depth*, int *border*, ArrayBufferView *srcData*[, uint *srcOffset*=0[, uint *srcLengthOverride*=0]]);

void **compressedTexSubImage3D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *zoffset*, sizei *level*, sizei *level*, sizei *depth*, enum *format*, ArrayBufferView *srcData*[, uint *srcOffset*=0[,uint *srcLengthOverride*=0]]);

void **compressedTexImage2D**(enum *target*, int *level*, enum *internalformat*, sizei *width*, sizei *height*, int *border*, sizei *imageSize*, intptr *offset*);

void **compressedTexSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, sizei *width*, sizei *height*, enum *format*, sizei *imageSize*, intptr *offset*);

void **compressedTexImage3D**(enum *target*, int *level*, enum *internalformat*, sizei *width*, sizei *height*, sizei *depth*, int *border*, sizei *imageSize*, intptr *offset*);

void **compressedTexSubImage3D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, int *zoffset*, *width*, sizei *height*, sizei *depth*, enum *format*, sizei *imageSize*, intptr *offset*);

Whole Framebuffer Operations [5.14.3]

void **clear**(bitfield *mask*);
mask: Bitwise OR of {COLOR, DEPTH, STENCIL}_BUFFER_BIT

void **clearColor**(clampf *red*, clampf *green*, clampf *blue*, clampf *alpha*);

void **clearDepth**(float *depth*);
depth: Clamped to the range 0 to 1.

void **clearStencil**(int *s*);

void **colorMask**(bool *red*, bool *green*, bool *blue*, bool *alpha*);

void **depthMask**(bool *flag*);

void **stencilMask**(uint *mask*);

void **stencilMaskSeparate**(enum *face*, uint *mask*);
face: FRONT, BACK, FRONT_AND_BACK

Multiple Render Targets [3.7.11]

void **drawBuffers**(sequence<GLenum> *buffers*);

void **clearBufferfv**(enum *buffer*, int *drawbuffer*, Float32List *values*[, uint *srcOffset*=0]);

void **clearBufferiv**(enum *buffer*, int *drawbuffer*, Int32List *values*[, uint *srcOffset*=0]);

void **clearBufferuiv**(enum *buffer*, int *drawbuffer*, Uint32List *values*[, uint *srcOffset*=0]);

void **clearBufferfi**(enum *buffer*, int *drawbuffer*, float *depth*, int *stencil*);

Use the function based on the color buffer type:
clearBufferfv: floating point; **clearBufferfv**: fixed point
clearBufferiv: signed integer **clearBufferiv**: signed integer;
clearBufferfi: DEPTH_STENCIL buffers

Sampler Objects [3.7.13]

WebGLSampler? **createSampler**();

void **deleteSampler**(WebGLSampler? *sampler*);

[WebGLHandlesContextLoss] boolean **isSampler**(WebGLSampler? *sampler*);

void **bindSampler**(uint *unit*, WebGLSampler? *sampler*);

void **samplerParameteri**(WebGLSampler *sampler*, enum *pname*, int *param*);

void **samplerParameterf**(WebGLSampler *sampler*, enum *pname*, float *param*);
pname: TEXTURE_COMPARE_{FUNC, MODE}, TEXTURE_MAG_FILTER, TEXTURE_MAX_LOD, TEXTURE_MIN_{FILTER, LOD}, TEXTURE_WRAP_{R, S, T}

any **getSamplerParameter**(WebGLSampler *sampler*, enum *pname*);
pname: See *pname* for **samplerParameterf**

Query Objects [3.7.12]

WebGLQuery? **createQuery**();

void **deleteQuery**(WebGLQuery? *query*);

[WebGLHandlesContextLoss] boolean **isQuery**(WebGLQuery? *query*);

void **beginQuery**(enum *target*, WebGLQuery *query*);

void **endQuery**(enum *target*)

WebGLQuery? **getQuery**(enum *target*, enum *pname*);
target: ANY_SAMPLES_PASSED[_CONSERVATIVE], TRANSFORM_FEEDBACK_PRIMITIVES_WRITTEN
pname: CURRENT_QUERY

any **getQueryParameter**(WebGLQuery *query*, enum *pname*);
pname: QUERY_RESULT[_AVAILABLE]

Transform Feedback [3.7.15]

Captures output variable values written by the vertex shader.

WebGLTransformFeedback? **createTransformFeedback**();

void **deleteTransformFeedback**(WebGLTransformFeedback? *transformFeedback*);

[WebGLHandlesContextLoss] boolean **isTransformFeedback**(WebGLTransformFeedback? *transformFeedback*);

void **bindTransformFeedback**(enum *target*, WebGLTransformFeedback? *transformFeedback*);

void **beginTransformFeedback**(enum *primitiveMode*);

void **endTransformFeedback**();

void **pauseTransformFeedback**();

void **resumeTransformFeedback**();

void **transformFeedbackVaryings**(WebGLProgram *program*, sequence<DOMString> *varyings*, enum *bufferMode*);

WebGLActiveInfo? **getTransformFeedbackVarying**(WebGLProgram *program*, uint *index*);

Sync Objects [3.7.14]

Synchronize execution between the GL server and the client.

WebGLSync? **fenceSync**(enum *condition*, bitfield *flags*)

[WebGLHandlesContextLoss] boolean **isSync**(WebGLSync? *sync*);

void **deleteSync**(WebGLSync? *sync*);

enum **clientWaitSync**(WebGLSync *sync*, bitfield *flags*, uint64 *timeout*);
flags: SYNC_FLUSH_COMMANDS_BIT

void **waitSync**(WebGLSync *sync*, bitfield *flags*, int64 *timeout*);
timeout: TIMEOUT_IGNORED

any **getSyncParameter**(WebGLSync *sync*, enum *pname*);
pname: OBJECT_TYPE, SYNC_{CONDITION, FLAGS, STATUS}

Uniform Buffer Objects [3.7.16]

Provides the storage for named uniform blocks.

void **bindBufferBase**(enum *target*, uint *index*, WebGLBuffer? *buffer*);

void **bindBufferRange**(enum *target*, uint *index*, WebGLBuffer? *buffer*, intptr *offset*, sizeiptr *size*);

sequence<uint>? **getUniformIndices**(WebGLProgram *program*, sequence<DOMString> *uniformNames*);

any **getActiveUniforms**(WebGLProgram *program*, sequence<uint> *uniformIndices*, enum *pname*);
pname: UNIFORM_{BLOCK_INDEX, SIZE, TYPE, OFFSET}, UNIFORM_{ARRAY, MATRIX}_STRIDE, UNIFORM_IS_ROW_MAJOR

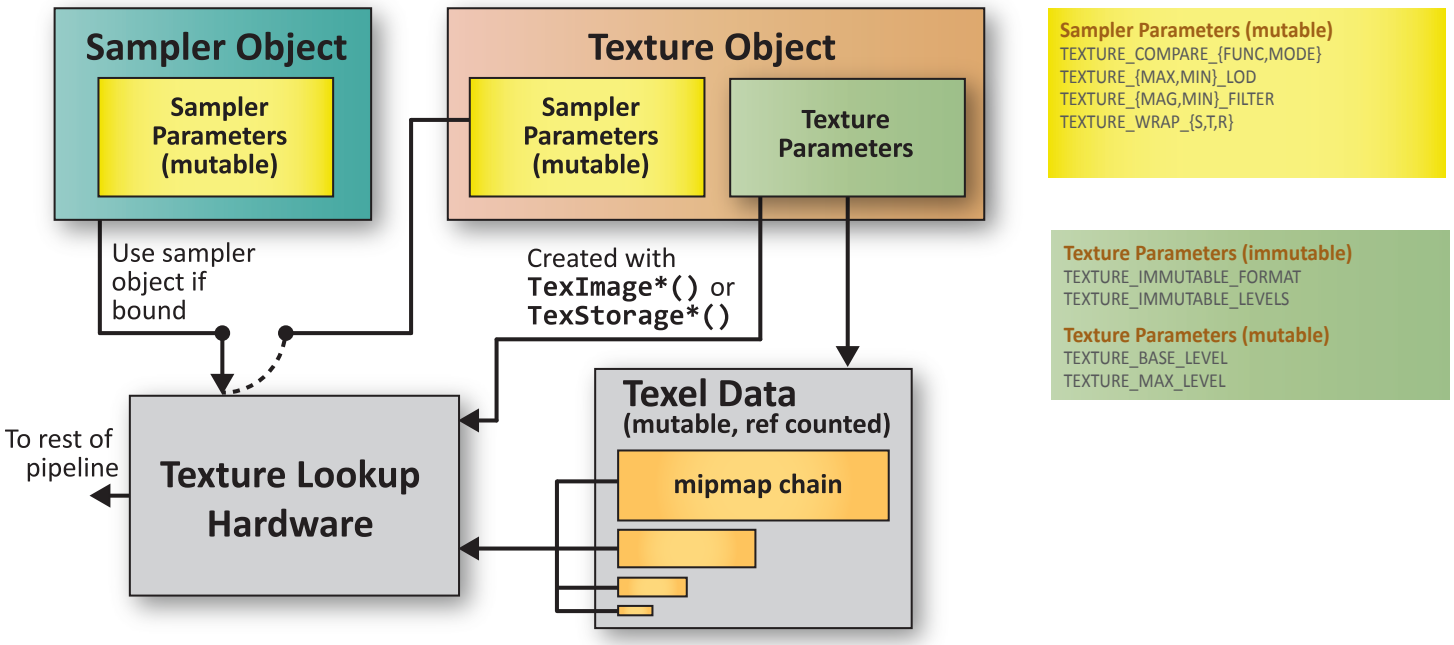
uint **getUniformBlockIndex**(WebGLProgram *program*, DOMString *uniformBlockName*);

any **getActiveUniformBlockParameter**(WebGLProgram *program*, uint *uniformBlockIndex*, enum *pname*);
pname: UNIFORM_BLOCK_{BINDING, DATA_SIZE}, UNIFORM_BLOCK_ACTIVE_UNIFORMS, UNIFORM_BLOCK_ACTIVE_UNIFORM_INDICES, UNIFORM_BLOCK_REFERENCED_BY_VERTEX_SHADER, UNIFORM_BLOCK_REFERENCED_BY_FRAGMENT_SHADER

DOMString? **getActiveUniformBlockName**(WebGLProgram *program*, uint *uniformBlockIndex*);

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

OpenGL Texture Object and Sampler State



Sized Texture Color Formats [3.7.11]

If an application wants to store the texture at a certain resolution or in a certain format, it can request the resolution and format with *internalFormat*. The following table shows the sized internal formats indicating whether they are color renderable or texture filterable.
In **Color Renderable** column, a red **Y** means the aiff extension EXT_color_buffer_float is enabled. In **Texture Filterable** column, a red **Y** means the iff extension OES_texture_float_linear is enabled.

Internal Format	Format	Type	Color Renderable	Texture Filterable
GL_R8	GL_RED	GL_UNSIGNED_BYTE	Y	Y
GL_R8_SNORM	GL_RED	GL_BYTE		Y
GL_R16F	GL_RED	GL_HALF_FLOAT, GL_FLOAT	Y	Y
GL_R32F	GL_RED	GL_FLOAT	Y	Y
GL_R8UI	GL_RED_INTEGER	GL_UNSIGNED_BYTE	Y	
GL_R8I	GL_RED_INTEGER	GL_BYTE	Y	
GL_R16UI	GL_RED_INTEGER	GL_UNSIGNED_SHORT	Y	
GL_R16I	GL_RED_INTEGER	GL_SHORT	Y	
GL_R32UI	GL_RED_INTEGER	GL_UNSIGNED_INT	Y	
GL_R32I	GL_RED_INTEGER	GL_INT	Y	
GL_RG8	GL_RG	GL_UNSIGNED_BYTE	Y	Y
GL_RG8_SNORM	GL_RG	GL_BYTE		Y
GL_RG16F	GL_RG	GL_HALF_FLOAT,GL_FLOAT	Y	Y
GL_RG32F	GL_RG	GL_FLOAT	Y	Y
GL_RG8UI	GL_RG_INTEGER	GL_UNSIGNED_BYTE	Y	
GL_RG8I	GL_RG_INTEGER	GL_BYTE	Y	
GL_RG16UI	GL_RG_INTEGER	GL_UNSIGNED_SHORT	Y	
GL_RG16I	GL_RG_INTEGER	GL_SHORT	Y	
GL_RG32UI	GL_RG_INTEGER	GL_UNSIGNED_INT	Y	
GL_RG32I	GL_RG_INTEGER	GL_INT	Y	
GL_RGB8	GL_RGB	GL_UNSIGNED_BYTE	Y	Y
GL_SRGB8	GL_RGB	GL_UNSIGNED_BYTE		Y
GL_RGB565	GL_RGB	GL_UNSIGNED_BYTE, GL_UNSIGNED_SHORT_5_6_5	Y	Y
GL_RGB8_SNORM	GL_RGB	GL_BYTE		Y
GL_R11F_G11F_B10F	GL_RGB	GL_UNSIGNED_INT_10F_11F_11F_REV, GL_HALF_FLOAT, GL_FLOAT	Y	Y
GL_RGB9_E5	GL_RGB	GL_UNSIGNED_INT_5_9_9_9_REV, GL_HALF_FLOAT, GL_FLOAT		Y
GL_RGB16F	GL_RGB	GL_HALF_FLOAT, GL_FLOAT		Y
GL_RGB32F	GL_RGB	GL_FLOAT		Y
GL_RGB8UI	GL_RGB_INTEGER	GL_UNSIGNED_BYTE		
GL_RGB8I	GL_RGB_INTEGER	GL_BYTE		
GL_RGB16UI	GL_RGB_INTEGER	GL_UNSIGNED_SHORT		
GL_RGB16I	GL_RGB_INTEGER	GL_SHORT		
GL_RGB32UI	GL_RGB_INTEGER	GL_UNSIGNED_INT		
GL_RGB32I	GL_RGB_INTEGER	GL_INT		
GL_RGBA8	GL_RGBA	GL_UNSIGNED_BYTE	Y	Y
GL_SRGB8_ALPHA8	GL_RGBA	GL_UNSIGNED_BYTE	Y	Y
GL_RGBA8_SNORM	GL_RGBA	GL_BYTE		Y
GL_RGB5_A1	GL_RGBA	GL_UNSIGNED_BYTE, GL_UNSIGNED_SHORT_5_5_5_1, GL_UNSIGNED_INT_2_10_10_10_REV	Y	Y
GL_RGBA4	GL_RGBA	GL_UNSIGNED_BYTE, GL_UNSIGNED_SHORT_4_4_4_4	Y	Y
GL_RGB10_A2	GL_RGBA	GL_UNSIGNED_INT_2_10_10_10_REV	Y	Y
GL_RGBA16F	GL_RGBA	GL_HALF_FLOAT, GL_FLOAT	Y	Y
GL_RGBA32F	GL_RGBA	GL_FLOAT	Y	Y
GL_RGBA8UI	GL_RGBA_INTEGER	GL_UNSIGNED_BYTE	Y	
GL_RGBA8I	GL_RGBA_INTEGER	GL_BYTE	Y	
GL_RGB10_A2UI	GL_RGBA_INTEGER	GL_UNSIGNED_INT_2_10_10_10_REV	Y	
GL_RGBA16UI	GL_RGBA_INTEGER	GL_UNSIGNED_SHORT	Y	
GL_RGBA16I	GL_RGBA_INTEGER	GL_SHORT	Y	
GL_RGBA32I	GL_RGBA_INTEGER	GL_INT	Y	
GL_RGBA32UI	GL_RGBA_INTEGER	GL_UNSIGNED_INT	Y	

The OpenGL® ES Shading Language is two closely-related languages which are used to create shaders for the vertex and fragment processors contained in the WebGL, OpenGL, and OpenGL ES processing pipelines. WebGL 2.0 is based on OpenGL ES 3.0.

[n.n.n] and **[Table n.n]** refer to sections and tables in the OpenGL ES Shading Language 3.0 specification at www.khronos.org/registry/gles/

Types [4.1]

A shader can aggregate these using arrays and structures to build more complex types. There are no pointer types.

Basic Types

void	no function return value or empty parameter list
bool	Boolean
int, uint	signed, unsigned integer
float	floating scalar
vec2, vec3, vec4	n-component floating point vector
bvec2, bvec3, bvec4	Boolean vector
ivec2, ivec3, ivec4	signed integer vector
uvec2, uvec3, uvec4	unsigned integer vector
mat2, mat3, mat4	2x2, 3x3, 4x4 float matrix
mat2x2, mat2x3, mat2x4	2x2, 2x3, 2x4 float matrix
mat3x2, mat3x3, mat3x4	3x2, 3x3, 3x4 float matrix
mat4x2, mat4x3, mat4x4	4x2, 4x3, 4x4 float matrix

Floating Point Sampler Types (opaque)

sampler2D, sampler3D	access a 2D or 3D texture
samplerCube	access cube mapped texture
samplerCubeShadow	access cube map depth texture with comparison
sampler2DShadow	access 2D depth texture with comparison
sampler2DArray	access 2D array texture
sampler2DArrayShadow	access 2D array depth texture with comparison

Signed Integer Sampler Types (opaque)

isampler2D, isampler3D	access an integer 2D or 3D texture
isamplerCube	access integer cube mapped texture
isampler2DArray	access integer 2D array texture

Unsigned Integer Sampler Types (opaque)

usampler2D, usampler3D	access unsigned integer 2D or 3D texture
usamplerCube	access unsigned integer cube mapped texture
usampler2DArray	access unsigned integer 2D array texture

Structures and Arrays [4.1.8, 4.1.9]

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

Arrays	float foo[3]; Structures, blocks, and structure members can be arrays. Only 1-dimensional arrays supported.

Preprocessor [3.4]

Preprocessor Directives

The number sign (#) can be immediately preceded or followed in its line by spaces or horizontal tabs.

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

Examples of Preprocessor Directives

- "#version 300 es" must appear in the first line of a shader program written in GLSL ES version 3.00. If omitted, the shader will be treated as targeting version 1.00.
- #extension *extension_name* : *behavior*, where *behavior* can be require, enable, warn, or disable; and where *extension_name is* the extension supported by the compiler
- **#pragma** optimize({on, off}) - enable or disable shader optimization (default on)
  #pragma debug({on, off}) - enable or disable compiling shaders with debug information (default off)

Predefined Macros

__LINE__	Decimal integer constant that is one more than the number of preceding newlines in the current source string
__FILE__	Decimal integer constant that says which source string number is currently being processed.
__VERSION__	Decimal integer, e.g.: 300
GL_ES	Defined and set to integer 1 if running on an OpenGL-ES Shading Language.

Qualifiers

Storage Qualifiers [4.3]

Variable declarations may be preceded by one storage qualifier.

none	(Default) local read/write memory, or input parameter
const	Compile-time constant, or read-only function parameter
in **centroid in**	Linkage into a shader from a previous stage
out **centroid out**	Linkage out of a shader to a subsequent stage
uniform	Value does not change across the primitive being processed, uniforms form the linkage between a shader, OpenGL ES, and the application

The following interpolation qualifiers for shader outputs and inputs may procede **in**, **centroid in**, **out**, or **centroid out**.

smooth	Perspective correct interpolation
flat	No interpolation

Interface Blocks [4.3.7]

Uniform variable declarations can be grouped into named interface blocks, for example:

```
uniform Transform {
  mat4 ModelViewProjectionMatrix;
  uniform mat3 NormalMatrix;   // restatement of qualifier
  float Deformation;
}
```

Layout Qualifiers [4.3.8]

layout(*layout-qualifier*) *block-declaration*
layout(*layout-qualifier*) **in/out/uniform**
layout(*layout-qualifier*) **in/out/uniform** *declaration*

Input Layout Qualifiers [4.3.8.1]

For all shader stages:
location = *integer-constant*

Output Layout Qualifiers [4.3.8.2]

For all shader stages:
location = *integer-constant*

Uniform Block Layout Qualifiers [4.3.8.3]

Layout qualifier identifiers for uniform blocks:

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

Parameter Qualifiers [4.4]

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

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

Precision and Precision Qualifiers [4.5]

Any floating point, integer, or sampler declaration can have the type preceded by one of these precision qualifiers:

highp	Satisfies minimum requirements for the vertex language.
mediump	Range and precision is between that provided by **lowp** and **highp**.
lowp	Range and precision can be less than **mediump**, but still represents all color values for any color channel.

Ranges and precisions for precision qualifiers (FP=floating point):

	FP Range	FP Magnitude Range	FP Precision	Integer Range	
				Signed	Unsigned
highp	$(-2^{126}, 2^{127})$	0.0, $(2^{-126}, 2^{127})$	Relative 2^{-24}	$[-2^{31}, 2^{31}-1]$	$[0, 2^{32}-1]$
mediump	$(-2^{14}, 2^{14})$	$(2^{-14}, 2^{14})$	Relative 2^{-10}	$[-2^{15}, 2^{15}-1]$	$[0, 2^{16}-1]$
lowp	(−2, 2)	$(2^{-8}, 2)$	Absolute 2^{-8}	$[-2^{7}, 2^{7}-1]$	$[0, 2^{8}-1]$

A precision statement establishes a default precision qualifier for subsequent int, float, and sampler declarations, e.g.:

precision **highp** int;

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

Order of Qualification [4.7]

When multiple qualifications are present, they must follow a strict order. This order is either:

invariant, interpolation, storage, precision

or:

storage, parameter, precision

Operators and Expressions

Operators [5.1]

Numbered in order of precedence. The relational and equality operators > < <= >= == != evaluate to a Boolean. To compare vectors component-wise, use functions such as lessThan(), equal(), etc. [8.7].

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

Vector Components [5.5]

In addition to array numeric subscript syntax, names of vector components are denoted by a single letter. Components can be swizzled and replicated, e.g.: pos.xx, pos.zy

{x, y, z, w}	Use when accessing vectors that represent points or normals
{r, g, b, a}	Use when accessing vectors that represent colors
{s, t, p, q}	Use when accessing vectors that represent texture coordinates

Aggregate Operations and Constructors

Matrix Constructor Examples [5.4.2]

```
mat2(float)                    // init diagonal
mat2(vec2, vec2);              // column-major order
mat2(float, float,
     float, float);            // column-major order
```

Structure Constructor Example [5.4.3]

```
struct light {
    float intensity;
    vec3 pos;
};
light lightVar = light(3.0, vec3(1.0, 2.0, 3.0));
```

Matrix Components [5.6]

Access components of a matrix with array subscripting syntax. For example:

```
mat4 m;          // m represents a matrix
m[1] = vec4(2.0); // sets second column 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 column 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 component-wise +/-
m = m * m;       // linear algebraic multiply
m = v * m;       // row vector * matrix linear algebraic multiply
m = m * v;       // matrix * column vector linear algebraic multiply
f = dot(v, v);   // vector dot product
v = cross(v, v); // vector cross product
m = matrixCompMult(m, m);   // component-wise multiply
```

(more examples ↗)

Structure Operations [5.7]

Select structure fields using the period (.) operator. Valid operators are:

.	field selector
== !=	equality
=	assignment

Array Operations [5.7]

Array elements are accessed using the array subscript operator "[ ]". For example:

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

The size of an array can be determined using the **.length()** operator. For example:

```
for (i = 0; i < a.length(); i++)
    a[i] = 0.0;
```

Statements and Structure

Iteration and Jumps [6]

Entry	void main()

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

Jump	break, continue, return discard // Fragment shader only

Selection	if ( ) { }
	if ( ) { } else { }
	switch ( ) { break, case }

Built-In Inputs, Outputs, and Constants [7]

Shader programs use special variables to communicate with fixed-function parts of the pipeline. Output special variables may be read back after writing. Input special variables are read-only. All special variables have global scope.

Vertex Shader Special Variables [7.1]

Inputs:

```
int     gl_VertexID;     // integer index
int     gl_InstanceID;   // instance number
```

Outputs:

```
out gl_PerVertex {
    vec4    gl_Position;     // transformed vertex position in clip coordinates
    float   gl_PointSize;    // transformed point size in pixels (point rasterization only)
};
```

Fragment Shader Special Variables [7.2]

Inputs:

```
highp vec4    gl_FragCoord;    // fragment position within frame buffer
bool          gl_FrontFacing;  // fragment belongs to a front-facing primitive
mediump vec2  gl_PointCoord;   // 0.0 to 1.0 for each component
```

Outputs:

```
highp float   gl_FragDepth;    // depth range
```

Built-In Constants With Minimum Values [7.3]

Built-in Constant	Minimum value
const mediump int gl_MaxVertexAttribs	16
const mediump int gl_MaxVertexUniformVectors	256
const mediump int gl_MaxVertexOutputVectors	16
const mediump int gl_MaxFragmentInputVectors	15
const mediump int gl_MaxVertexTextureImageUnits	16
const mediump int gl_MaxCombinedTextureImageUnits	32
const mediump int gl_MaxTextureImageUnits	16
const mediump int gl_MaxFragmentUniformVectors	224
const mediump int gl_MaxDrawBuffers	4
const mediump int gl_MinProgramTexelOffset	-8
const mediump int gl_MaxProgramTexelOffset	7

Built-In Uniform State [7.4]

As an aid to accessing OpenGL ES processing state, the following uniform variables are built into the OpenGL ES Shading Language.

```
struct gl_DepthRangeParameters {
    float near;    // n
    float far;     // f
    float diff;    // f - n
};
uniform gl_DepthRangeParameters gl_DepthRange;
```

Built-In Functions

Angle & Trigonometry Functions [8.1]

Component-wise operation. Parameters specified as *angle* are assumed to be in units of radians. T is float, vec2, vec3, vec4.

T **radians** (T *degrees*);	degrees to radians
T **degrees** (T *radians*);	radians to degrees
T **sin** (T *angle*);	sine
T **cos** (T *angle*);	cosine
T **tan** (T *angle*);	tangent
T **asin** (T *x*);	arc sine
T **acos** (T *x*);	arc cosine
T **atan** (T *y*, T *x*); T **atan** (T *y_over_x*);	arc tangent
T **sinh** (T *x*);	hyperbolic sine
T **cosh** (T *x*);	hyperbolic cosine
T **tanh** (T *x*);	hyperbolic tangent
T **asinh** (T *x*);	arc hyperbolic sine; inverse of sinh
T **acosh** (T *x*);	arc hyperbolic cosine; non-negative inverse of cosh
T **atanh** (T *x*);	arc hyperbolic tangent; inverse of tanh

Exponential Functions [8.2]

Component-wise operation. T is float, vec2, vec3, vec4.

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

Common Functions [8.3]

Component-wise operation. T is float and vec*n*, TI is int and ivec*n*, TU is uint and uvec*n*, and TB is bool and bvec*n*, where *n* is 2, 3, or 4.

T **abs**(T *x*); TI **abs**(TI *x*);	absolute value
T **sign**(T *x*); TI **sign**(TI *x*);	returns -1.0, 0.0, or 1.0
T **floor**(T *x*);	nearest integer <= *x*
T **trunc** (T *x*);	nearest integer a such that |*a*| <= |*x*|
T **round** (T *x*);	round to nearest integer
T **roundEven** (T *x*);	round to nearest integer
T **ceil**(T *x*);	nearest integer >= *x*
T **fract**(T *x*);	*x* - **floor**(*x*)

T **mod**(T *x*, T *y*); T **mod**(T *x*, float *y*); T **modf**(T *x*, out T *i*);	modulus
T **min**(T *x*, T *y*); TI **min**(TI *x*, TI *y*); TU **min**(TU *x*, TU *y*); T **min**(T *x*, float *y*); TI **min**(TI *x*, int *y*); TU **min**(TU *x*, uint *y*);	minimum value
T **max**(T *x*, T *y*); TI **max**(TI *x*, TI *y*); TU **max**(TU *x*, TU *y*); T **max**(T *x*, float *y*); TI **max**(TI *x*, int *y*); TU **max**(TU *x*, uint *y*);	maximum value
T **clamp**(T *x*, T *minVal*, T *maxVal*); TI **clamp**(V *x*, TI *minVal*, TI *maxVal*); TU **clamp**(TU *x*, TU *minVal*, TU *maxVal*); T **clamp**(T *x*, float *minVal*, float *maxVal*); TI **clamp**(TI *x*, int *minVal*, int *maxVal*); TU **clamp**(TU *x*, uint *minVal*, uint *maxVal*);	**min**(**max**(*x*, *minVal*), *maxVal*)
T **mix**(T *x*, T *y*, T *a*); T **mix**(T *x*, T *y*, float *a*);	linear blend of *x* and *y*
T **mix**(T *x*, T *y*, TB *a*);	Selects vector source for each returned component
T **step**(T *edge*, T *x*); T **step**(float *edge*, T *x*);	0.0 if *x* < *edge*, else 1.0

(more Common Functions ↗)

Built-In Functions (continued)

Common Functions (continued)

T **smoothstep**(T *edge0*, T *edge1*, T *x*); T **smoothstep**(float *edge0*, float *edge1*, T *x*);	clamp and smooth
TB **isnan**(T *x*);	true if *x* is a NaN
TB **isinf**(T *x*);	true if *x* is positive or negative infinity
TI **floatBitsToInt**(T *value*); TU **floatBitsToUint**(T *value*);	highp integer, preserving float bit level representation
T **intBitsToFloat**(TI *value*); T **uintBitsToFloat**(TU *value*);	highp float, preserving integer bit level representation

Floating-point Pack and Unpack Functions [8.4]

uint **packSnorm2x16**(vec2 *v*); uint **packUnorm2x16**(vec2 *v*);	convert two floats to fixed point and pack into an integer
vec2 **unpackSnorm2x16**(uint *p*); vec2 **unpackUnorm2x16**(uint *p*);	unpack fixed point value pair into floats
uint **packHalf2x16**(vec2 *v*);	convert two floats into half-precision floats and pack into an integer
vec2 **unpackHalf2x16**(uint *v*);	unpack half value pair into full floats

Geometric Functions [8.5]

These functions operate on vectors as vectors, not component-wise. T is float, vec2, vec3, vec4.

float **length**(T *x*);	length of vector
float **distance**(T *p0*, T *p1*);	distance between points
float **dot**(T *x*, T *y*);	dot product
vec3 **cross**(vec3 *x*, vec3 *y*);	cross product
T **normalize**(T *x*);	normalize vector to length 1
T **faceforward**(T *N*, T *I*, T *Nref*);	returns *N* if **dot**(*Nref*, *I*) < 0, else *-N*
T **reflect**(T *I*, T *N*);	reflection direction *I* - 2 * **dot**(*N*,*I*) * *N*
T **refract**(T *I*, T *N*, float *eta*);	refraction vector

Matrix Functions [8.6]

Type mat is any matrix type.

mat **matrixCompMult**(mat *x*, mat *y*);	multiply *x* by *y* component-wise
mat2 **outerProduct**(vec2 *c*, vec2 *r*); mat3 **outerProduct**(vec3 *c*, vec3 *r*); mat4 **outerProduct**(vec4 *c*, vec4 *r*);	linear algebraic column vector * row vector
mat2x3 **outerProduct**(vec3 *c*, vec2 *r*); mat3x2 **outerProduct**(vec2 *c*, vec3 *r*); mat2x4 **outerProduct**(vec4 *c*, vec2 *r*); mat4x2 **outerProduct**(vec2 *c*, vec4 *r*); mat3x4 **outerProduct**(vec4 *c*, vec3 *r*); mat4x3 **outerProduct**(vec3 *c*, vec4 *r*);	linear algebraic column vector * row vector
mat2 **transpose**(mat2 *m*); mat3 **transpose**(mat3 *m*); mat4 **transpose**(mat4 *m*); mat2x3 **transpose**(mat3x2 *m*); mat3x2 **transpose**(mat2x3 *m*); mat2x4 **transpose**(mat4x2 *m*); mat4x2 **transpose**(mat2x4 *m*); mat3x4 **transpose**(mat4x3 *m*); mat4x3 **transpose**(mat3x4 *m*);	transpose of matrix *m*
float **determinant**(mat2 *m*); float **determinant**(mat3 *m*); float **determinant**(mat4 *m*);	determinant of matrix *m*
mat2 **inverse**(mat2 *m*); mat3 **inverse**(mat3 *m*); mat4 **inverse**(mat4 *m*);	inverse of matrix *m*

Vector Relational Functions [8.7]

Compare *x* and *y* component-wise. Input and return vector sizes for a particular call must match. Type bvec is bvec*n*; vec is vec*n*; ivec is ivec*n*; uvec is uvec*n*; (where *n* is 2, 3, or 4). T is union of vec and ivec.

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

Texture Lookup Functions [8.8]

The function textureSize returns the dimensions of level *lod* for the texture bound to sampler, as described in [2.11.9] of the OpenGL ES 3.0 specification, under "Texture Size Query". The initial "g" in a type name is a placeholder for nothing, "i", or "u".

highp ivec{2,3}	**textureSize**(gsampler{2,3}D *sampler*, int *lod*);
highp ivec2	**textureSize**(gsamplerCube *sampler*, int *lod*);
highp ivec2	**textureSize**(sampler2DShadow *sampler*, int *lod*);
highp ivec2	**textureSize**(samplerCubeShadow *sampler*, int *lod*);
highp ivec3	**textureSize**(sampler2DArray *sampler*, int *lod*);
highp ivec3	**textureSize**(sampler2DArrayShadow *sampler*, int *lod*);

Texture lookup functions using samplers are available to vertex and fragment shaders. The initial "g" in a type name is a placeholder for nothing, "i", or "u".

gvec4	**texture**(gsampler{2,3}D *sampler*, vec{2,3} *P* [, float *bias*]);
gvec4	**texture**(gsamplerCube *sampler*, vec3 *P* [, float *bias*]);
float	**texture**(sampler2DShadow *sampler*, vec3 *P* [, float *bias*]);
float	**texture**(samplerCubeShadow *sampler*, vec4 *P* [, float *bias*]);
gvec4	**texture**(gsampler2DArray *sampler*, vec3 *P* [, float *bias*]);
float	**texture**(sampler2DArrayShadow *sampler*, vec4 *P*);
gvec4	**textureProj**(gsampler2D *sampler*, vec{3,4} *P* [, float *bias*]);
gvec4	**textureProj**(gsampler3D *sampler*, vec4 *P* [, float *bias*]);
float	**textureProj**(sampler2DShadow *sampler*, vec4 *P* [, float *bias*]);
gvec4	**textureLod**(gsampler{2,3}D *sampler*, vec{2,3} *P*, float *lod*);
gvec4	**textureLod**(gsamplerCube *sampler*, vec3 *P*, float *lod*);
float	**textureLod**(sampler2DShadow *sampler*, vec3 *P*, float *lod*);
gvec4	**textureLod**(gsampler2DArray *sampler*, vec3 *P*, float *lod*);
gvec4	**textureOffset**(gsampler2D *sampler*, vec2 *P*, ivec2 *offset* [, float *bias*]);
gvec4	**textureOffset**(gsampler3D *sampler*, vec3 *P*, ivec3 *offset* [, float *bias*]);
float	**textureOffset**(sampler2DShadow *sampler*, vec3 *P*, ivec2 *offset* [, float *bias*]);
gvec4	**textureOffset**(gsampler2DArray *sampler*, vec3 *P*, ivec2 *offset* [, float *bias*]);
gvec4	**texelFetch**(gsampler2D *sampler*, ivec2 *P*, int *lod*);
gvec4	**texelFetch**(gsampler3D *sampler*, ivec3 *P*, int *lod*);
gvec4	**texelFetch**(gsampler2DArray *sampler*, ivec3 *P*, int *lod*);
gvec4	**texelFetchOffset**(gsampler2D *sampler*, ivec2 *P*, int *lod*, ivec2 *offset*);
gvec4	**texelFetchOffset**(gsampler3D *sampler*, ivec3 *P*, int *lod*, ivec3 *offset*);
gvec4	**texelFetchOffset**(gsampler2DArray *sampler*, ivec3 *P*, int *lod*, ivec2 *offset*);
gvec4	**textureProjOffset**(gsampler2D *sampler*, vec3 *P*, ivec2 *offset* [, float *bias*]);
gvec4	**textureProjOffset**(gsampler2D *sampler*, vec4 *P*, ivec2 *offset* [, float *bias*]);
gvec4	**textureProjOffset**(gsampler3D *sampler*, vec4 *P*, ivec3 *offset* [, float *bias*]);
float	**textureProjOffset**(sampler2DShadow *sampler*, vec4 *P*, ivec2 *offset* [, float *bias*]);

Texture Lookup Functions (continued)

gvec4	**textureLodOffset**(gsampler2D *sampler*, vec2 *P*, float *lod*, ivec2 *offset*);
gvec4	**textureLodOffset**(gsampler3D *sampler*, vec3 *P*, float *lod*, ivec3 *offset*);
float	**textureLodOffset**(sampler2DShadow *sampler*, vec3 *P*, float *lod*, ivec2 *offset*);
gvec4	**textureLodOffset**(gsampler2DArray *sampler*, vec3 *P*, float *lod*, ivec2 *offset*);
gvec4	**textureProjLod**(gsampler2D *sampler*, vec3 *P*, float *lod*);
gvec4	**textureProjLod**(gsampler2D *sampler*, vec4 *P*, float *lod*);
gvec4	**textureProjLod**(gsampler3D *sampler*, vec4 *P*, float *lod*);
float	**textureProjLod**(sampler2DShadow *sampler*, vec4 *P*, float *lod*);
gvec4	**textureProjLodOffset**(gsampler2D *sampler*, vec3 *P*, float *lod*, ivec2 *offset*);
gvec4	**textureProjLodOffset**(gsampler2D *sampler*, vec4 *P*, float *lod*, ivec2 *offset*);
gvec4	**textureProjLodOffset**(gsampler3D *sampler*, vec4 *P*, float *lod*, ivec3 *offset*);
float	**textureProjLodOffset**(sampler2DShadow *sampler*, vec4 *P*, float *lod*, ivec2 *offset*);
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*);
float	**textureGrad**(sampler2DShadow *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*);
float	**textureGrad**(samplerCubeShadow *sampler*, vec4 *P*, vec3 *dPdx*, vec3 *dPdy*);
gvec4	**textureGrad**(gsampler2DArray *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*);
float	**textureGrad**(sampler2DArrayShadow *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*);
gvec4	**textureGradOffset**(gsampler2D *sampler*, vec2 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*);
gvec4	**textureGradOffset**(gsampler3D *sampler*, vec3 *P*, vec3 *dPdx*, vec3 *dPdy*, ivec3 *offset*);
float	**textureGradOffset**(sampler2DShadow *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*);
gvec4	**textureGradOffset**(gsampler2DArray *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*);
float	**textureGradOffset**(sampler2DArrayShadow *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*);
gvec4	**textureProjGrad**(gsampler2D *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*);
gvec4	**textureProjGrad**(gsampler2D *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*);
gvec4	**textureProjGrad**(gsampler3D *sampler*, vec4 *P*, vec3 *dPdx*, vec3 *dPdy*);
float	**textureProjGrad**(sampler2DShadow *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*);
gvec4	**textureProjGradOffset**(gsampler2D *sampler*, vec3 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*);
gvec4	**textureProjGradOffset**(gsampler2D *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*);
gvec4	**textureProjGradOffset**(gsampler3D *sampler*, vec4 *P*, vec3 *dPdx*, vec3 *dPdy*, ivec3 *offset*);
float	**textureProjGradOffset**(sampler2DShadow *sampler*, vec4 *P*, vec2 *dPdx*, vec2 *dPdy*, ivec2 *offset*);

Fragment Processing Functions [8.9]

Approximated using local differencing.

T **dFdx**(T *p*);	Derivative in *x*
T **dFdy**(T *p*);	Derivative in *y*
T **fwidth**(T *p*);	**abs** (**dFdx** (*p*)) + **abs** (**dFdy** (*p*));