

WebGL® is a software interface for accessing graphics hardware from within a web browser. Based on OpenGL ES 2.0, WebGL allows a programmer to specify the objects and operations involved in producing high-quality graphical images, specifically color images of 3D objects.

- **[n.n.n]** refers to sections in the WebGL 1.0 specification, available at www.khronos.org/webgl
- **Content marked in purple** does **not** have a corresponding function in OpenGL ES. The OpenGL ES 2.0 specification is available at www.khronos.org/registry/gles

WebGL function calls behave identically to their OpenGL ES counterparts unless otherwise noted.

Interfaces

Interfaces are optional requests and may be ignored by an implementation. See **getContextAttributes** for actual values.

WebGLContextAttributes [5.2]

This interface contains requested drawing surface attributes and is passed as the second parameter to **getContext**.

Attributes:

alpha If true, requests a drawing buffer with an alpha channel for the purposes of performing OpenGL destination alpha operations and compositing with the page.	Default: true
depth If true, requests drawing buffer with a depth buffer of at least 16 bits.	Default: true
stencil If true, requests a stencil buffer of at least 8 bits.	Default: false
antialias If true, requests drawing buffer with antialiasing using its choice of technique (multisample/supersample) and quality.	Default: true
premultipliedAlpha If true, requests drawing buffer which contains colors with premultiplied alpha. (Ignored if Alpha is false.)	Default: true
preserveDrawingBuffer If true, requests that contents of the drawing buffer remain in between frames, at potential performance cost.	Default: false

Per-Fragment Operations [5.13.3]

void **blendColor**(float red, float green, float blue, float 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
Note: Src and dst factors 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**
Note: Src and dst factors may not both reference constant color
void **depthFunc**(enum func)
func: NEVER, ALWAYS, LESS, EQUAL, LEQUAL, GREATER, GEQUAL, NOTEQUAL
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**

Detect and Enable Extensions [5.13.14]

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

The WebGL Context and getContext() [2.5]

This object manages OpenGL state and renders to the a drawing buffer, which must also be created at the same time of as the context creation. Create the **WebGLRenderingContext** object and drawing buffer by calling the **getContext** method of a given **HTMLCanvasElement** object with the exact string 'webgl'. The drawing buffer is also created by **getContext**.

For example:

```
<!DOCTYPE html>
<html><body>
  <canvas id="c"></canvas>
  <script type="text/javascript">
    var canvas = document.getElementById("c");
    var gl = canvas.getContext("webgl");
    gl.clearColor(1.0, 0.0, 0.0, 1.0);
    gl.clear(gl.COLOR_BUFFER_BIT);
  </script>
</body></html>
```

WebGLObject [5.3]

This is the parent interface for all WebGL resource objects.

Resource interface objects:

WebGLBuffer [5.4]	OpenGL Buffer Object.
WebGLProgram [5.6]	OpenGL Program Object.
WebGLRenderbuffer [5.7]	OpenGL Renderbuffer Object.
WebGLShader [5.8]	OpenGL Shader Object.
WebGLTexture [5.9]	OpenGL Texture Object.
WebGLUniformLocation [5.10]	Location of a uniform variable in a shader program.
WebGLActiveInfo [5.11]	Information returned from calls to getActiveAttrib and getActiveUniform . Has the following read-only properties: name, location, size, type.

WebGLRenderingContext [5.13]

This is the principal interface in WebGL. The functions listed on this reference card are available within this interface.

Attributes:

canvas A reference to the canvas element which created this context.	Type: HTMLCanvasElement
drawingBufferWidth The actual width of the drawing buffer, which may differ from the width attribute of the HTMLCanvasElement if the implementation is unable to satisfy the requested width or height.	Type: GLsizei
drawingBufferHeight The actual height of the drawing buffer, which may differ from the height attribute of the HTMLCanvasElement if the implementation is unable to satisfy the requested width or height	Type: GLsizei

ArrayBuffer and Typed Arrays [5.12]

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.

Buffers

ArrayBuffer(ulong *byteLength*)
ulong *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.
ulong *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.
ArrayBuffer *buffer*: Read-only, buffer backing this view
ulong *byteOffset*: Read-only, byte offset of view start in buffer
ulong *length*: Read-only, number of elements in this view

Other Properties

ulong *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, [optional] ulong *offset*)
set(*type*[]) *other*, [optional] ulong *offset*)
Replace elements in this view with those from other, starting at optional offset.
ViewType **subset**(long *begin*, [optional] long *end*)
Return a subset of this view, referencing the same underlying buffer.

Whole Framebuffer Operations [5.13.3]

void **clear**(ulong *mask*) [5.13.11]
mask: Bitwise OR of {COLOR, DEPTH, STENCIL}_BUFFER_BIT
void **clearColor**(float red, float green, float blue, float 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

Buffer Objects [5.13.5]

Once bound, buffers may not be rebound with a different Target.
void **bindBuffer**(enum target, Object *buffer*)
target: ARRAY_BUFFER, ELEMENT_ARRAY_BUFFER
void **bufferData**(enum target, long size, enum usage)
target: ARRAY_BUFFER, ELEMENT_ARRAY_BUFFER
usage: STATIC_DRAW, STREAM_DRAW, DYNAMIC_DRAW
void **bufferData**(enum target, Object *data*, enum usage)
target and usage: Same as for **bufferData** above

void **bufferSubData**(enum target, long offset, Object *data*)
target: ARRAY_BUFFER, ELEMENT_ARRAY_BUFFER
Object **createBuffer**()
Note: Corresponding OpenGL ES function is **GenBuffers**
void **deleteBuffer**(Object *buffer*)
any **getBufferParameter**(enum target, enum pname)
target: ARRAY_BUFFER, ELEMENT_ARRAY_BUFFER
pname: BUFFER_SIZE, BUFFER_USAGE
bool **isBuffer**(Object *buffer*)

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)

Rasterization [5.13.3]

void **cullFace**(enum mode)
mode: BACK, FRONT_AND_BACK, FRONT
void **frontFace**(enum mode)
mode: CCW, CW
void **lineWidth**(float width)
void **polygonOffset**(float factor, float units)

Detect context lost events [5.13.13]

bool **isContextLost**()

Programs and Shaders [5.13.9]

Rendering with OpenGL ES 2.0 requires the use of shaders. Shaders must be loaded with a source string (**shaderSource**), compiled (**compileShader**), and attached to a program (**attachShader**) which must be linked (**linkProgram**) and then used (**useProgram**).

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**(Object *program*, enum *pname*)

Note: Corresponding OpenGL ES function is **GetProgramiv**
pname: DELETE_STATUS, LINK_STATUS, VALIDATE_STATUS, ATTACHED_SHADERS, ACTIVE_ATTRIBUTES, UNIFORMS

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

any **getShaderParameter**(Object *shader*, enum *pname*)

Note: 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 [5.13.10]

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

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

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

Object **getActiveAttrib**(Object *program*, uint *index*)

Object **getActiveUniform**(Object *program*, uint *index*)

ulong **getAttribLocation**(Object *program*, string *name*)

any **getUniform**(Object *program*, uint *location*)

uint **getUniformLocation**(Object *program*, string *name*)

any **getVertexAttrib**(uint *index*, enum *pname*)
pname: CURRENT_VERTEX_ATTRIB, VERTEX_ATTRIB_ARRAY_BUFFER_BINDING, ENABLED, SIZE, STRIDE, TYPE, NORMALIZED

long **getVertexAttribOffset**(uint *index*, enum *pname*)

Note: Corres. OpenGL ES function is **GetVertexAttribPointerv**
pname: VERTEX_ATTRIB_ARRAY_POINTER

void **uniform**[1234][fiv](uint *location*, ...)

void **uniform**[1234][fiv](uint *location*, Array *value*)

void **uniformMatrix**[234]fv(uint *location*, bool *transpose*, Array *transpose*: FALSE

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

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

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

Framebuffer Objects [5.13.6]

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

void **bindFramebuffer**(enum *target*, Object *framebuffer*)
target: FRAMEBUFFER

enum **checkFramebufferStatus**(enum *target*)

target: FRAMEBUFFER
Returns: FRAMEBUFFER_COMPLETE, UNSUPPORTED, FRAMEBUFFER_INCOMPLETE_ATTACHMENT, DIMENSIONS, MISSING_ATTACHMENT

Texture Objects [5.13.8]

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*) [5.13.3]

texture: [TEXTURE0.TEXTUREi] where i = MAX_COMBINED_TEXTURE_IMAGE_UNITS - 1

void **bindTexture**(enum *target*, Object *texture*)
target: TEXTURE_2D, 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
internalformat: ALPHA, LUMINANCE, LUMINANCE_ALPHA, RGB[A]

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**()

Note: Corresponding OpenGL ES function is **GenTextures**

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

void **generateMipmap**(enum *target*)
target: TEXTURE_2D, TEXTURE_CUBE_MAP

any **getTexParameter**(enum *target*, enum *pname*)
target: TEXTURE_2D, TEXTURE_CUBE_MAP
pname: TEXTURE_WRAP_S, T, TEXTURE_MIN, MAG_FILTER

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

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

void **texImage2D**(enum *target*, int *level*, enum *internalformat*, enum *format*, enum *type*, Object *object*)

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

target: See *target* for **copyTexImage2D**
internalformat: See *internalformat* for **copyTexImage2D**
format: ALPHA, RGB, RGBA, LUMINANCE, LUMINANCE_ALPHA
type: UNSIGNED_BYTE, UNSIGNED_SHORT_5_6_5, UNSIGNED_SHORT_4_4_4_4, UNSIGNED_SHORT_5_5_5_1
object: pixels of type ImageData, image of type HTMLImageElement, canvas of type HTMLCanvasElement, video of type HTMLVideoElement

void **texParameterf**(enum *target*, enum *pname*, float *param*)
target: TEXTURE_2D, TEXTURE_CUBE_MAP
pname: TEXTURE_WRAP_S, T, TEXTURE_MIN, MAG_FILTER

void **texParameteri**(enum *target*, enum *pname*, int *param*)
target: TEXTURE_2D, TEXTURE_CUBE_MAP
pname: TEXTURE_WRAP_S, T, TEXTURE_MIN, MAG_FILTER

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

void **texSubImage2D**(enum *target*, int *level*, int *xoffset*, int *yoffset*, enum *format*, enum *type*, Object *object*)

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

target: TEXTURE_CUBE_MAP_POSITIVE_X, Y, Z, TEXTURE_CUBE_MAP_NEGATIVE_X, Y, Z
format and *type*: See *format* and *type* for **texImage2D**
object: Same as for **texImage2D**

Writing to the Draw Buffer [5.13.11]

When rendering is directed to drawing buffer, OpenGL ES 2.0 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*, long *count*)
mode: POINTS, LINE_STRIP, LINE_LOOP, LINES, TRIANGLE_STRIP, TRIANGLE_FAN, TRIANGLES
first: May not be a negative value.

void **drawElements**(enum *mode*, long *count*, enum *type*, long *offset*)

mode: POINTS, LINE_STRIP, LINE_LOOP, LINES, TRIANGLE_STRIP, TRIANGLE_FAN, TRIANGLES
type: UNSIGNED_BYTE, UNSIGNED_SHORT

Object **createFramebuffer**()

Note: Corresponding OpenGL ES function is **GenFramebuffers**

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

void **framebufferRenderbuffer**(enum *target*, enum *attachment*, enum *renderbuffertarget*, Object *renderbuffer*)

target: FRAMEBUFFER
attachment: COLOR_ATTACHMENT0, {DEPTH, STENCIL}_ATTACHMENT
renderbuffertarget: RENDERBUFFER

bool **isFramebuffer**(Object *framebuffer*)

Special Functions [5.13.3]

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, [NUM][COMPRESSED_TEXTURE_FORMATS, CULL_FACE_MODE], CURRENT_PROGRAM, DEPTH_BITS, CLEAR_VALUE, FUNC, RANGE, TEST, WRITEMASK, ELEMENT_ARRAY_BUFFER_BINDING, DITHER, FRAMEBUFFER_BINDING, FRONT_FACE, GENERATE_MIPMAP_HINT, LINE_WIDTH, MAX_COMBINED_TEXTURE_IMAGE_UNITS, MAX_CUBE_MAP_TEXTURE_RENDERBUFFER_TEXTURE_SIZE, MAX_VARYING_VECTORS, MAX_VERTEX_ATTRIBS, TEXTURE_IMAGE_UNITS, UNIFORM_VECTORS, MAX_VIEWPORT_DIMS, PACK_ALIGNMENT, POLYGON_OFFSET_FACTOR, FILL, UNITS, RENDERBUFFER_BINDING, RENDERER, SAMPLE_BUFFERS, SAMPLE_COVERAGE, INVERT, VALUE, SAMPLES, SCISSOR_BOX, TEST, SHADING_LANGUAGE_VERSION, STENCIL_BITS, CLEAR_VALUE, TEST, STENCIL_BACK_FAIL, FUNC, REFVALUE_MASK, WRITEMASK, STENCIL_BACK_PASS_DEPTH_FAIL, PASS, TEXTURE_BINDING_2D, CUBE_MAP, UNPACK_ALIGNMENT, UNPACK_COLORSPACE_CONVERSION_WEBGL, FLIP_Y_WEBGL, PREMULTIPLY_ALPHA_WEBGL, VENDOR, VERSION, VIEWPORT

void **hint**(enum *target*, enum *mode*)

target: GENERATE_MIPMAP_HINT
hint: FASTEST, NICEST, DONT_CARE

bool **isEnabled**(enum *cap*)

cap: See *cap* for **disable**

void **pixelStorei**(enum *pname*, int *param*)
pname: UNPACK_ALIGNMENT, PACK_ALIGNMENT, UNPACK_FLIP_Y_WEBGL, PREMULTIPLY_ALPHA_WEBGL, UNPACK_COLORSPACE_CONVERSION_WEBGL

Renderbuffer Objects [5.13.7]

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**()

Note: Corresponding OpenGL ES function is **GenRenderbuffers**

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

any **getRenderbufferParameter**(enum *target*, enum *pname*)

target: RENDERBUFFER
pname: RENDERBUFFER_WIDTH, HEIGHT, INTERNAL_FORMAT, RENDERBUFFER_RED, GREEN, BLUE, ALPHA, DEPTH, STENCIL_SIZE

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

void **renderbufferStorage**(enum *target*, enum *internalformat*, long *width*, long *height*)

target: RENDERBUFFER
internalformat: DEPTH_COMPONENT16, RGBA4, RGB5_A1, RGB565, STENCIL_INDEX8

Read Back Pixels [5.13.12]

Pixels in the current framebuffer can be read back into an ArrayBufferView object.

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

void **framebufferTexture2D**(enum *target*, enum *attachment*, enum *textarget*, Object *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

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 OpenGL ES processing pipeline.

[n.n.n] refers to sections in the OpenGL ES Shading Language 1.0 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	signed integer
float	floating scalar
vec2, vec3, vec4	n-component floating point vector
bvec2, bvec3, bvec4	Boolean vector
ivec2, ivec3, ivec4	signed integer vector
mat2, mat3, mat4	2x2, 3x3, 4x4 float matrix
sampler2D	access a 2D texture
samplerCube	access cube mapped texture

Structures and Arrays [4.1.8, 4.1.9]

Structures	<pre>struct type-name { members } struct-name[];</pre> // optional variable declaration, // optionally an array
Arrays	<pre>float foo[3]; * structures and blocks can be arrays * only 1-dimensional arrays supported * structure members can be arrays</pre>

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.

	Operator	Description	Associativity
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
7.	< > <= >=	relational	L - R
8.	== !=	equality	L - R
12.	&&	logical and	L - R
13.	^^	logical exclusive or	L - R
14.		logical inclusive or	L - R
15.	?:	selection (Selects one entire operand. Use mix() to select individual components of vectors.)	L - R
16.	= += -= *= /=	assignment arithmetic assignments	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

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	#version	#line

Examples of Preprocessor Directives

- “#version 100” in a shader program specifies that the program is written in GLSL ES version 1.00. It is optional. If used, it must occur before anything else in the program other than whitespace or comments.
- #extension extension_name : behavior, where behavior can be require, enable, warn, or disable; and where extension_name is the extension supported by the compiler

Predefined Macros

__LINE__	Decimal integer constant that is one more than the number of preceding new-lines in the current source string
__VERSION__	Decimal integer, e.g.: 100
GL_ES	Defined and set to integer 1 if running on an OpenGL-ES Shading Language.
GL_FRAGMENT_PRECISION_HIGH	1 if highp is supported in the fragment language, else undefined [4.5.4]

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
attribute	Linkage between a vertex shader and OpenGL ES for per-vertex data
uniform	Value does not change across the primitive being processed, uniforms form the linkage between a shader, OpenGL ES, and the application
varying	Linkage between a vertex shader and fragment shader for interpolated data

Uniform [4.3.4]

Use to declare global variables whose values are the same across the entire primitive being processed. All uniform variables are read-only. Use uniform qualifiers with any basic data types, to declare a variable whose type is a structure, or an array of any of these. For example:

uniform vec4 lightPosition;

Varying [4.3.5]

The varying qualifier can be used only with the data types float, vec2, vec3, vec4, mat2, mat3, mat4, or arrays of these. Structures cannot be varying. Varying variables are required to have global scope. Declaration is as follows:

varying vec3 normal;

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

Aggregate Operations and Constructors

Matrix Constructor Examples [5.4]

```
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
```

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. Optional in the fragment language.
mediump	Satisfies minimum requirements for the fragment language. Its 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.

For example:

```
lowp float color;  
varying mediump vec2 Coord;  
lowp ivec2 foo(lowp mat3);  
highp mat4 m;
```

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

	FP Range	FP Magnitude Range	FP Precision	Integer Range
highp	(-2 ⁶² , 2 ⁶²)	(2 ⁻⁶² , 2 ⁶²)	Relative 2 ⁻¹⁶	(-2 ¹⁶ , 2 ¹⁶)
mediump	(-2 ¹⁴ , 2 ¹⁴)	(2 ⁻¹⁴ , 2 ¹⁴)	Relative 2 ⁻¹⁰	(-2 ¹⁰ , 2 ¹⁰)
lowp	(-2, 2)	(2 ⁻⁸ , 2)	Absolute 2 ⁻⁸	(-2 ⁸ , 2 ⁸)

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 varying mediump 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 as follows.

invariant, storage, precision
storage, parameter, precision

Structure Operations [5.7]

Select structure fields using the period (.) operator. Other operators include:

.	field selector
== !=	equality
=	assignment

Array Operations [4.1.9]

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

diffuseColor += lightIntensity[3] * NdotLi;

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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]

Outputs:

Variable	Description	Units or coordinate system
highp vec4 gl_Position;	transformed vertex position	clip coordinates
mediump float gl_PointSize;	transformed point size (point rasterization only)	pixels

Fragment Shader Special Variables [7.2]

Fragment shaders may write to gl_FragColor or to one or more elements of gl_FragData[], but not both.

The size of the gl_FragData array is given by the built-in constant gl_MaxDrawBuffers.

Inputs:

Variable	Description	Units or coordinate system
mediump vec4 gl_FragCoord;	fragment position within frame buffer	window coordinates
bool gl_FrontFacing;	fragment belongs to a front-facing primitive	Boolean
mediump vec2 gl_PointCoord;	fragment position within a point (point rasterization only)	0.0 to 1.0 for each component

Outputs:

Variable	Description	Units or coordinate system
mediump vec4 gl_FragColor;	fragment color	RGBA color
mediump vec4 gl_FragData[n]	fragment color for color attachment <i>n</i>	RGBA color

Built-In Constants With Minimum Values [7.4]

Built-in Constant	Minimum value
const mediump int gl_MaxVertexAttribs	8
const mediump int gl_MaxVertexUniformVectors	128
const mediump int gl_MaxVaryingVectors	8
const mediump int gl_MaxVertexTextureImageUnits	0
const mediump int gl_MaxCombinedTextureImageUnits	8
const mediump int gl_MaxTextureImageUnits	8
const mediump int gl_MaxFragmentUniformVectors	16
const mediump int gl_MaxDrawBuffers	1

Built-In Uniform State [7.5]

Specifies depth range in window coordinates. If an implementation does not support high precision in the fragment language, and state is listed as highp, then that state will only be available as mediump in the fragment language.

```
struct gl_DepthRangeParameters {
    highp float near;    // n
    highp float far;    // f
    highp 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)	arc tangent
T atan(T y_over_x)	arc tangent

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, vec2, vec3, vec4.

T abs(T x)	absolute value
T sign(T x)	returns -1.0, 0.0, or 1.0
T floor(T x)	nearest integer $\leq x$
T ceil(T x)	nearest integer $\geq x$
T fract(T x)	$x - \text{floor}(x)$
T mod(T x, T y)	modulus
T mod(T x, float y)	modulus
T min(T x, T y)	minimum value
T min(T x, float y)	minimum value
T max(T x, T y)	maximum value
T max(T x, float y)	maximum value
T clamp(T x, T minVal, T maxVal)	
T clamp(T x, float minVal, float 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 step(T edge, T x)	
T step(float edge, T x)	0.0 if $x < \text{edge}$, else 1.0
T smoothstep(T edge0, T edge1, T x)	
T smoothstep(float edge0, float edge1, T x)	clip and smooth

Geometric Functions [8.4]

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 $I - 2 * \text{dot}(N, I) * N$
T refract(T I, T N, float eta)	refraction vector

Matrix Functions [8.5]

Type mat is any matrix type.

mat matrixCompMult(mat x, mat y) multiply x by y component-wise

Vector Relational Functions [8.6]

Compare x and y component-wise. Sizes of input and return vectors for a particular call must match. Type bvec is bvecn; vec is vecn; ivec is ivec_n (where *n* is 2, 3, or 4). T is the union of vec and ivec.

bvec lessThan(T x, T y)	$x < y$
bvec lessThanEqual(T x, T y)	$x \leq y$
bvec greaterThan(T x, T y)	$x > y$
bvec greaterThanEqual(T x, T y)	$x \geq y$
bvec equal(T x, T y)	$x == y$
bvec equal(bvec x, bvec y)	
bvec notEqual(T x, T y)	$x != y$
bvec notEqual(bvec x, bvec 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 [8.7]

Available only in vertex shaders.

```
vec4 texture2DLod(sampler2D sampler, vec2 coord, float lod)
vec4 texture2DProjLod(sampler2D sampler, vec3 coord, float lod)
vec4 texture2DProjLod(sampler2D sampler, vec4 coord, float lod)
vec4 textureCubeLod(samplerCube sampler, vec3 coord, float lod)
```

Available only in fragment shaders.

```
vec4 texture2D(sampler2D sampler, vec2 coord, float bias)
vec4 texture2DProj(sampler2D sampler, vec3 coord, float bias)
vec4 texture2DProj(sampler2D sampler, vec4 coord, float bias)
vec4 textureCube(samplerCube sampler, vec3 coord, float bias)
```

Available in vertex and fragment shaders.

```
vec4 texture2D(sampler2D sampler, vec2 coord)
vec4 texture2DProj(sampler2D sampler, vec3 coord)
vec4 texture2DProj(sampler2D sampler, vec4 coord)
vec4 textureCube(samplerCube sampler, vec3 coord)
```

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 { }
Jump	break, continue, return discard // Fragment shader only
Entry	void main()

Sample Program

A shader pair that applies diffuse and ambient lighting to a textured object.

Vertex Shader

```
uniform mat4 mvp_matrix; // model-view-projection matrix
uniform mat3 normal_matrix; // normal matrix
uniform vec3 ec_light_dir; // light direction in eye coords

attribute vec4 a_vertex; // vertex position
attribute vec3 a_normal; // vertex normal
attribute vec2 a_texcoord; // texture coordinates

varying float v_diffuse;
varying vec2 v_texcoord;

void main(void)
{
    // put vertex normal into eye coords
    vec3 ec_normal = normalize(normal_matrix * a_normal);

    // emit diffuse scale factor, texcoord, and position
    v_diffuse = max(dot(ec_light_dir, ec_normal), 0.0);
    v_texcoord = a_texcoord;
    gl_Position = mvp_matrix * a_vertex;
}
```

Fragment Shader

```
precision mediump float;

uniform sampler2D t_reflectance;
uniform vec4 i_ambient;

varying float v_diffuse;
varying vec2 v_texcoord;

void main (void)
{
    vec4 color = texture2D(t_reflectance, v_texcoord);
    gl_FragColor = color * (vec4(v_diffuse) + i_ambient);
}
```



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