OpenCL (Open Computing Language) is a multi-vendor open standard for general-purpose parallel programming of heterogeneous systems that include CPUs, GPUs, and other processors. OpenCL provides a uniform programming environment for software developers to write efficient, portable code for high-performance compute servers, desktop computer systems, and handheld devices.

[n.n.n] refers to the section in the OpenCL Specification.
[n.n.n] refers to the section in the OpenCL Extension Specification
Text shown in purple is as per the OpenCL Extension Specification.

Specifications are available at www.khronos.org/opencl.

The OpenCL Runtime

Command Queues [5.1]

cl_command_queue **clCreateCommandQueue** (
  cl_context *context*, cl_device_id *device*,
  cl_command_queue_properties *properties*,
  cl_int **errcode_ret*)

properties: CL_QUEUE_PROFILING_ENABLE,
  CL_QUEUE_OUT_OF_ORDER_EXEC_MODE_ENABLE

cl_int **clRetainCommandQueue** (
  cl_command_queue *command_queue*)

cl_int **clReleaseCommandQueue** (
  cl_command_queue *command_queue*)

cl_int **clGetCommandQueueInfo** (
  cl_command_queue *command_queue*,
  cl_command_queue_info *param_name*,
  size_t *param_value_size*,
  void **param_value*,
  size_t **param_value_size_ret*)

param_name: CL_QUEUE_CONTEXT,
  CL_QUEUE_DEVICE,
  CL_QUEUE_REFERENCE_COUNT,
  CL_QUEUE_PROPERTIES

The OpenCL Platform Layer

The OpenCL platform layer implements platform-specific features that allow applications to query OpenCL devices, device configuration information, and to create OpenCL contexts using one or more devices.

Querying Platform Info and Devices [4.1, 4.2]

cl_int **clGetPlatformIDs** (cl_uint *num_entries*,
  cl_platform_id **platforms*, cl_uint **num_platforms*)

cl_int **clGetPlatformInfo** (cl_platform_id *platform*,
  cl_platform_info *param_name*,
  size_t *param_value_size*, void **param_value*,
  size_t **param_value_size_ret*)

param_name: CL_PLATFORM_{PROFILE, VERSION},
  CL_PLATFORM_{NAME, VENDOR, EXTENSIONS}

cl_int **clGetDeviceIDs** (cl_platform_id *platform*,
  cl_device_type *device_type*, cl_uint *num_entries*,
  cl_device_id **devices*, cl_uint **num_devices*)

device_type: CL_DEVICE_TYPE_{ACCELERATOR, ALL, CPU},
  CL_DEVICE_TYPE_{CUSTOM, DEFAULT, GPU}

cl_int **clGetDeviceInfo** (cl_device_id *device*,
  cl_device_info *param_name*, size_t *param_value_size*,
  void **param_value*, size_t **param_value_size_ret*)

param_name:
  CL_DEVICE_{NAME, VENDOR, PROFILE, TYPE},
  CL_DEVICE_NATIVE_VECTOR_WIDTH_{CHAR, INT},
  CL_DEVICE_NATIVE_VECTOR_WIDTH_{LONG, SHORT},
  CL_DEVICE_NATIVE_VECTOR_WIDTH_{DOUBLE, HALF},
  CL_DEVICE_NATIVE_VECTOR_WIDTH_FLOAT,
  CL_DEVICE_PREFERRED_VECTOR_WIDTH_{CHAR, INT},
  CL_DEVICE_PREFERRED_VECTOR_WIDTH_{LONG, SHORT},
  CL_DEVICE_PREFERRED_VECTOR_WIDTH_{DOUBLE, HALF},
  CL_DEVICE_PREFERRED_VECTOR_WIDTH_FLOAT,
  CL_DEVICE_PREFERRED_INTEROP_USER_SYNC,
  CL_DEVICE_ADDRESS_BITS, CL_DEVICE_AVAILABLE,
  CL_DEVICE_BUILT_IN_KERNELS,
  CL_DEVICE_COMPILER_AVAILABLE,
  CL_DEVICE_{DOUBLE, HALF, SINGLE}_FP_CONFIG,
  CL_DEVICE_ENDIAN_LITTLE, CL_DEVICE_EXTENSIONS,
  CL_DEVICE_ERROR_CORRECTION_SUPPORT,
  CL_DEVICE_EXECUTION_CAPABILITIES,
  CL_DEVICE_GLOBAL_MEM_CACHE_{SIZE, TYPE},
  CL_DEVICE_GLOBAL_MEM_{CACHELINE_SIZE, SIZE},
  CL_DEVICE_HOST_UNIFIED_MEMORY,
  CL_DEVICE_IMAGE_MAX_{ARRAY, BUFFER}_SIZE,
  CL_DEVICE_IMAGE_SUPPORT,
  CL_DEVICE_IMAGE2D_MAX_{WIDTH, HEIGHT},
  CL_DEVICE_IMAGE3D_MAX_{WIDTH, HEIGHT, DEPTH},
  CL_DEVICE_LOCAL_MEM_{TYPE, SIZE},
  CL_DEVICE_MAX_{READ, WRITE}_IMAGE_ARGS,
  CL_DEVICE_MAX_CLOCK_FREQUENCY,
  CL_DEVICE_MAX_COMPUTE_UNITS,
  CL_DEVICE_MAX_CONSTANT_{ARGS,BUFFER_SIZE},
  CL_DEVICE_MAX_{MEM_ALLOC, PARAMETER}_SIZE,
  CL_DEVICE_MAX_SAMPLERS,
  CL_DEVICE_MAX_WORK_GROUP_SIZE,
  CL_DEVICE_MAX_WORK_ITEM_{DIMENSIONS, SIZES},
  CL_DEVICE_MEM_BASE_ADDR_ALIGN,
  CL_DEVICE_OPENCL_C_VERSION, CL_DEVICE_PARENT_DEVICE,
  CL_DEVICE_PARTITION_AFFINITY_DOMAIN,
  CL_DEVICE_PARTITION_MAX_SUB_DEVICES,
  CL_DEVICE_PARTITION_{PROPERTIES, TYPE},
  CL_DEVICE_PLATFORM, CL_DEVICE_PRINTF_BUFFER_SIZE,
  CL_DEVICE_PROFILING_TIMER_RESOLUTION,
  CL_DEVICE_QUEUE_PROPERTIES,
  CL_DEVICE_REFERENCE_COUNT,
  CL_DEVICE_VENDOR_ID, CL_{DEVICE, DRIVER}_VERSION

Partitioning a Device [4.3]

cl_int **clCreateSubDevices** (cl_device_id *in_device*,
  const cl_device_partition_property **properties*,
  cl_uint *num_devices*, cl_device_id **out_devices*,
  cl_uint **num_devices_ret*)

properties: CL_DEVICE_PARTITION_EQUALLY,
  CL_DEVICE_PARTITION_BY_{COUNTS, AFFINITY_DOMAIN}
  (Affinity domains may be:
  CL_DEVICE_AFFINITY_DOMAIN_NUMA,
  CL_DEVICE_AFFINITY_DOMAIN_{L4, L3, L2, L1}_CACHE,
  CL_DEVICE_AFFINITY_DOMAIN_NEXT_PARTITIONABLE)

cl_int **clRetainDevice** (cl_device_id *device*)

cl_int **clReleaseDevice** (cl_device_id *device*)

Contexts [4.4]

cl_context **clCreateContext** (
  const cl_context_properties **properties*,
  cl_uint *num_devices*, const cl_device_id **devices*,
  void (CL_CALLBACK**pfn_notify*)
    (const char **errinfo*, const void **private_info*,
    size_t *cb*, void **user_data*),
  void **user_data*, cl_int **errcode_ret*)

properties: NULL or CL_CONTEXT_PLATFORM,
  CL_CONTEXT_INTEROP_USER_SYNC,
  CL_CONTEXT_{D3D10, D3D11}_DEVICE_KHR,
  CL_CONTEXT_ADAPTER_{D3D9, D3D9EX, DXVA}_KHR,
  CL_GL_CONTEXT_KHR, CL_CGL_SHAREGROUP_KHR,
  CL_{EGL, GLX}_DISPLAY_KHR, CL_WGL_HDC_KHR

cl_context **clCreateContextFromType** (
  const cl_context_properties **properties*,
  cl_device_type *device_type*,
  void (CL_CALLBACK **pfn_notify*)
    (const char **errinfo*, const void **private_info*,
    size_t *cb*, void **user_data*),
  void **user_data*, cl_int **errcode_ret*)

properties: See **clCreateContext**

cl_int **clRetainContext** (cl_context *context*)

cl_int **clReleaseContext** (cl_context *context*)

cl_int **clGetContextInfo** (cl_context *context*,
  cl_context_info *param_name*, size_t *param_value_size*,
  void **param_value*, size_t **param_value_size_ret*)

param_name: CL_CONTEXT_REFERENCE_COUNT,
  CL_CONTEXT_{DEVICES, NUM_DEVICES, PROPERTIES},
  CL_CONTEXT_D3D10_PREFER_SHARED_RESOURCES_KHR,
  CL_CONTEXT_D3D11_PREFER_SHARED_RESOURCES_KHR

Get CL Extension Function Pointers [9.2]

void* **clGetExtensionFunctionAddressForPlatform** (
  cl_platform_id *platform*, const char **funcname*)

Buffer Objects

Elements of a buffer object are stored sequentially and accessed using a pointer by a kernel executing on a device. Data is stored in the same format as it is accessed by the kernel.

Create Buffer Objects [5.2.1]

cl_mem **clCreateBuffer** (cl_context *context*,
  cl_mem_flags *flags*, size_t *size*, void **host_ptr*,
  cl_int **errcode_ret*)

flags: CL_MEM_READ_WRITE,
  CL_MEM_{WRITE, READ}_ONLY,
  CL_MEM_HOST_NO_ACCESS,
  CL_MEM_HOST_{READ, WRITE}_ONLY,
  CL_MEM_{USE, ALLOC, COPY}_HOST_PTR

cl_mem **clCreateSubBuffer** (cl_mem *buffer*,
  cl_mem_flags *flags*,
  cl_buffer_create_type *buffer_create_type*,
  const void **buffer_create_info*, cl_int **errcode_ret*)

flags: same as for **clCreateBuffer**

buffer_create_type: CL_BUFFER_CREATE_TYPE_REGION

Read, Write, Copy Buffer Objects [5.2.2]

cl_int **clEnqueueReadBuffer** (
  cl_command_queue *command_queue*, cl_mem *buffer*,
  cl_bool *blocking_read*, size_t *offset*, size_t *size*,
  void **ptr*, cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueReadBufferRect** (
  cl_command_queue *command_queue*, cl_mem *buffer*,
  cl_bool *blocking_read*, const size_t **buffer_origin*,
  const size_t **host_origin*, const size_t **region*,
  size_t *buffer_row_pitch*, size_t *buffer_slice_pitch*,
  size_t *host_row_pitch*, size_t *host_slice_pitch*,
  void **ptr*, cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueWriteBuffer** (
  cl_command_queue *command_queue*, cl_mem *buffer*,
  cl_bool *blocking_write*, size_t *offset*, size_t *size*,
  const void **ptr*, cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueWriteBufferRect** (
  cl_command_queue *command_queue*,
  cl_mem *buffer*, cl_bool *blocking_write*,
  const size_t **buffer_origin*, const size_t **host_origin*,
  const size_t **region*, size_t *buffer_row_pitch*,
  size_t *buffer_slice_pitch*, size_t *host_row_pitch*,
  size_t *host_slice_pitch*, const void **ptr*,
  cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueFillBuffer** (
  cl_command_queue *command_queue*,
  cl_mem *buffer*, const void **pattern*,
  size_t *pattern_size*, size_t *offset*, size_t *size*,
  cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueCopyBuffer** (
  cl_command_queue *command_queue*,
  cl_mem *src_buffer*, cl_mem *dst_buffer*,
  size_t *src_offset*, size_t *dst_offset*, size_t *size*,
  cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueCopyBufferRect** (
  cl_command_queue *command_queue*,
  cl_mem *src_buffer*, cl_mem *dst_buffer*,
  const size_t **src_origin*, const size_t **dst_origin*,
  const size_t **region*, size_t *src_row_pitch*,
  size_t *src_slice_pitch*, size_t *dst_row_pitch*,
  size_t *dst_slice_pitch*, cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

Map Buffer Objects [5.2.3]

void * **clEnqueueMapBuffer** (
  cl_command_queue *command_queue*, cl_mem *buffer*,
  cl_bool *blocking_map*, cl_map_flags *map_flags*,
  size_t *offset*, size_t *size*, cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*,
  cl_int **errcode_ret*)

map_flags: CL_MAP_{READ, WRITE},
  CL_MAP_WRITE_INVALIDATE_REGION

Memory Objects [5.4.1, 5.4.2]

cl_int **clRetainMemObject** (cl_mem *memobj*)

cl_int **clReleaseMemObject** (cl_mem *memobj*)

cl_int **clSetMemObjectDestructorCallback** (
  cl_mem *memobj*, void (CL_CALLBACK **pfn_notify*)
    (cl_mem *memobj*, void **user_data*),
  void **user_data*)

cl_int **clEnqueueUnmapMemObject** (
  cl_command_queue *command_queue*,
  cl_mem *memobj*, void **mapped_ptr*,
  cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

Migrate Memory Objects [5.4.4]

cl_int **clEnqueueMigrateMemObjects** (
  cl_command_queue *command_queue*,
  cl_uint *num_mem_objects*,
  const cl_mem **mem_objects*,
  cl_mem_migration_flags *flags*,
  cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

flags: CL_MIGRATE_MEM_OBJECT_HOST,
  CL_MIGRATE_MEM_OBJECT_CONTENT_UNDEFINED

Query Memory Object [5.4.5]

cl_int **clGetMemObjectInfo** (cl_mem *memobj*,
  cl_mem_info *param_name*, size_t *param_value_size*,
  void **param_value*, size_t **param_value_size_ret*)

param_name: CL_MEM_{TYPE, FLAGS, SIZE, HOST_PTR},
  CL_MEM_{MAP, REFERENCE}_COUNT, CL_MEM_OFFSET,
  CL_MEM_CONTEXT, CL_MEM_ASSOCIATED_MEMOBJECT,
  CL_MEM_{D3D10, D3D11}_RESOURCE_KHR,
  CL_MEM_DX9_MEDIA_ADAPTER_TYPE_KHR,
  CL_MEM_DX9_MEDIA_SURFACE_INFO_KHR

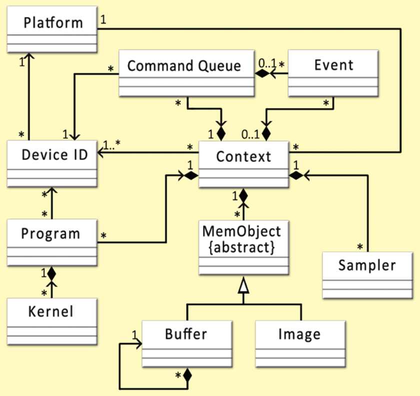
OpenCL Class Diagram [2.1]

The figure below describes the OpenCL specification as a class diagram using the Unified Modeling Language[1] (UML) notation. The diagram shows both nodes and edges which are classes and their relationships. As a simplification it shows only classes, and no attributes or operations.

Annotations

Relationships	
abstract classes	{abstract}
aggregations	◆
inheritance	△
relationship navigability	^

Cardinality	
many	*
one and only one	1
optionally one	0..1
one or more	1..*



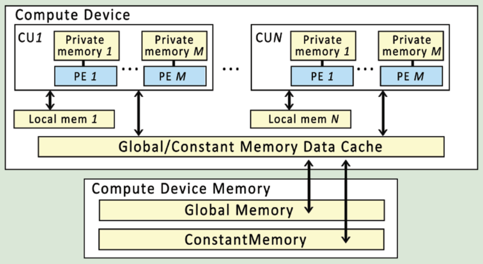
[1] Unified Modeling Language (http://www.uml.org/) is a trademark of Object Management Group (OMG).

OpenCL Device Architecture Diagram [3.3]

The table below shows memory regions with allocation and memory access capabilities.

	Global	Constant	Local	Private
Host	Dynamic allocation Read/Write access	Dynamic allocation Read/Write access	Dynamic allocation No access	No allocation No access
Kernel	No allocation Read/Write access	Static allocation Read-only access	Static allocation Read/Write access	Static allocation Read/Write access

This conceptual OpenCL device architecture diagram shows processing elements (PE), compute units (CU), and devices. The host is not shown.



Program Objects

Create Program Objects [5.6.1]

cl_program **clCreateProgramWithSource** (
cl_context *context*, cl_uint *count*, const char **strings*,
const size_t **lengths*, cl_int **errcode_ret*)

cl_program **clCreateProgramWithBinary** (
cl_context *context*, cl_uint *num_devices*,
const cl_device_id **device_list*, const size_t **lengths*,
const unsigned char ***binaries*, cl_int **binary_status*,
cl_int **errcode_ret*)

cl_program **clCreateProgramWithBuiltInKernels** (
cl_context *context*, cl_uint *num_devices*,
const cl_device_id **device_list*,
const char **kernel_names*, cl_int **errcode_ret*)

cl_int **clRetainProgram** (cl_program *program*)

cl_int **clReleaseProgram** (cl_program *program*)

Building Program Executables [5.6.2]

cl_int **clBuildProgram** (cl_program *program*,
cl_uint *num_devices*, const cl_device_id **device_list*,
const char **options*, void (CL_CALLBACK**pfn_notify*)
(cl_program *program,* void **user_data*),
void **user_data*)

Separate Compilation and Linking [5.6.3]

cl_int **clCompileProgram** (cl_program *program*,
cl_uint *num_devices*, const cl_device_id **device_list*,
const char **options*, cl_uint *num_input_headers*,
const cl_program **input_headers*,
const char ***header_include_names*,
void (CL_CALLBACK**pfn_notify*)
(cl_program *program,* void **user_data*),
void **user_data*)

cl_program **clLinkProgram** (cl_context *context*,
cl_uint *num_devices*, const cl_device_id **device_list*,
const char **options*, cl_uint *num_input_programs*,
const cl_program **input_programs*,
void (CL_CALLBACK**pfn_notify*)
(cl_program *program,* void **user_data*),
void **user_data,* cl_int **errcode_ret*)

Unload the OpenCL Compiler [5.6.6]

cl_int **clUnloadPlatformCompiler** (
cl_platform_id *platform*)

Query Program Objects [5.6.7]

cl_int **clGetProgramInfo** (cl_program *program*,
cl_program_info *param_name*, size_t *param_value_size*,
void **param_value*, size_t **param_value_size_ret*)

param_name: CL_PROGRAM_REFERENCE_COUNT,
CL_PROGRAM_{CONTEXT, NUM_DEVICES, DEVICES},
CL_PROGRAM_{SOURCE, BINARY_SIZES, BINARIES},
CL_PROGRAM_{NUM_KERNELS, KERNEL_NAMES}

cl_int **clGetProgramBuildInfo** (
cl_program *program*, cl_device_id *device*,
cl_program_build_info *param_name*,
size_t *param_value_size*, void **param_value*,
size_t **param_value_size_ret*)

param_name: CL_PROGRAM_BINARY_TYPE,
CL_PROGRAM_BUILD_{STATUS, OPTIONS, LOG}

Compiler Options [5.6.4]

Preprocessor: *(-D processed in order listed in* ***clBuildProgram*** *or* ***clCompileProgram****)*
-D *name* -D *name=definition* -I dir

Math intrinsics:
-cl-single-precision-constant -cl-denorms-are-zero
-cl-fp32-correctly-rounded-divide-sqrt

Optimization options:
-cl-opt-disable -cl-mad-enable
-cl-no-signed-zeros -cl-finite-math-only
-cl-unsafe-math-optimizations -cl-fast-relaxed-math

Warning request/suppress:
-w -Werror

Control OpenCL C language version:
-cl-std=CL1.1 // OpenCL 1.1 specification.
-cl-std=CL1.2 // OpenCL 1.2 specification.

Query kernel argument information:
-cl-kernel-arg-info

Linker Options [5.6.5]

Library linking options:
-create-library
-enable-link-options

Program linking options:
-cl-denorms-are-zero
-cl-no-signed-zeroes
-cl-unsafe-math-optimizations
-cl-finite-math-only
-cl-fast-relaxed-math

Kernel and Event Objects

Create Kernel Objects [5.7.1]

cl_kernel **clCreateKernel** (cl_program *program*,
const char **kernel_name*, cl_int **errcode_ret*)

cl_int **clCreateKernelsInProgram** (cl_program *program*,
cl_uint *num_kernels*, cl_kernel **kernels*,
cl_uint **num_kernels_ret*)

cl_int **clRetainKernel** (cl_kernel *kernel*)

cl_int **clReleaseKernel** (cl_kernel *kernel*)

Kernel Arguments and Queries [5.7.2, 5.7.3]

cl_int **clSetKernelArg** (cl_kernel *kernel*, cl_uint *arg_index*,
size_t *arg_size*, const void **arg_value*)

cl_int **clGetKernelInfo** (cl_kernel *kernel*,
cl_kernel_info *param_name*, size_t *param_value_size*,
void **param_value*, size_t **param_value_size_ret*)

param_name: CL_KERNEL_FUNCTION_NAME,
CL_KERNEL_NUM_ARGS, CL_KERNEL_REFERENCE_COUNT,
CL_KERNEL_{ATTRIBUTES, CONTEXT, PROGRAM}

cl_int **clGetKernelWorkGroupInfo** (
cl_kernel *kernel*, cl_device_id *device*,
cl_kernel_work_group_info *param_name*,
size_t *param_value_size*, void **param_value*,
size_t **param_value_size_ret*)

param_name: CL_KERNEL_GLOBAL_WORK_SIZE,
CL_KERNEL_[COMPILE_]WORK_GROUP_SIZE,
CL_KERNEL_{LOCAL, PRIVATE}_MEM_SIZE,
CL_KERNEL_PREFERRED_WORK_GROUP_SIZE_MULTIPLE

cl_int **clGetKernelArgInfo** (cl_kernel *kernel*,
cl_uint *arg_indx*, cl_kernel_arg_info *param_name*,
size_t *param_value_size*, void **param_value*,
size_t **param_value_size_ret*)

param_name:
CL_KERNEL_ARG_{ACCESS, ADDRESS, TYPE}_QUALIFIER,
CL_KERNEL_ARG_NAME, CL_KERNEL_ARG_TYPE_NAME

Execute Kernels [5.8]

cl_int **clEnqueueNDRangeKernel** (
cl_command_queue *command_queue*,
cl_kernel *kernel*, cl_uint *work_dim*,
const size_t **global_work_offset*,
const size_t **global_work_size*,
const size_t **local_work_size*,
cl_uint *num_events_in_wait_list*,
const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueTask** (
cl_command_queue *command_queue*,
cl_kernel *kernel*, cl_uint *num_events_in_wait_list*,
const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueNativeKernel** (cl_command_queue
command_queue, void (**user_func*)(void *),
void **args*, size_t *cb_args*, cl_uint *num_mem_objects*,
const cl_mem **mem_list*, const void ***args_mem_loc*,
cl_uint *num_events_in_wait_list*,
const cl_event **event_wait_list*, cl_event **event*)

Event Objects [5.9]

cl_event **clCreateUserEvent** (cl_context *context*,
cl_int **errcode_ret*)

cl_int **clSetUserEventStatus** (cl_event *event*,
cl_int *execution_status*)

cl_int **clWaitForEvents** (cl_uint *num_events*,
const cl_event **event_list*)

cl_int **clGetEventInfo** (cl_event *event*,
cl_event_info *param_name*, size_t *param_value_size*,
void **param_value*, size_t **param_value_size_ret*)

param_name: CL_EVENT_COMMAND_{QUEUE, TYPE},
CL_EVENT_{CONTEXT, REFERENCE_COUNT},
CL_EVENT_COMMAND_EXECUTION_STATUS

cl_int **clSetEventCallback** (cl_event *event*,
cl_int *command_exec_callback_type*,
void (CL_CALLBACK **pfn_event_notify*)
(cl_event *event*, cl_int *event_command_exec_status*,
void **user_data*),
void **user_data*)

cl_int **clRetainEvent** (cl_event *event*)

cl_int **clReleaseEvent** (cl_event *event*)

Markers, Barriers, and Waiting for Events [5.10]

cl_int **clEnqueueMarkerWithWaitList** (
cl_command_queue *command_queue*,
cl_uint *num_events_in_wait_list*,
const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueBarrierWithWaitList** (
cl_command_queue *command_queue*,
cl_uint *num_events_in_wait_list*,
const cl_event **event_wait_list*, cl_event **event*)

Profiling Operations [5.12]

cl_int **clGetEventProfilingInfo** (cl_event *event*,
cl_profiling_info *param_name*,
size_t *param_value_size*, void **param_value*,
size_t **param_value_size_ret*)

param_name: CL_PROFILING_COMMAND_QUEUED,
CL_PROFILING_COMMAND_{SUBMIT, START, END}

Flush and Finish [5.13]

cl_int **clFlush** (cl_command_queue *command_queue*)

cl_int **clFinish** (cl_command_queue *command_queue*)

Supported Data Types

The optional double scalar and vector types are supported if CL_DEVICE_DOUBLE_FP_CONFIG is not zero.

Built-in Scalar Data Types [6.1.1]

OpenCL Type	API Type	Description
bool	--	true (1) or false (0)
char	cl_char	8-bit signed
unsigned char, uchar	cl_uchar	8-bit unsigned
short	cl_short	16-bit signed
unsigned short, ushort	cl_ushort	16-bit unsigned
int	cl_int	32-bit signed
unsigned int, uint	cl_uint	32-bit unsigned
long	cl_long	64-bit signed
unsigned long, ulong	cl_ulong	64-bit unsigned
float	cl_float	32-bit float
double OPTIONAL	cl_double	64-bit. IEEE 754
half	cl_half	16-bit float (storage only)
size_t	--	32- or 64-bit unsigned integer
ptrdiff_t	--	32- or 64-bit signed integer
intptr_t	--	32- or 64-bit signed integer
uintptr_t	--	32- or 64-bit unsigned integer
void	void	void

Built-in Vector Data Types [6.1.2]

OpenCL Type	API Type	Description
char*n*	cl_char*n*	8-bit signed
uchar*n*	cl_uchar*n*	8-bit unsigned
short*n*	cl_short*n*	16-bit signed
ushort*n*	cl_ushort*n*	16-bit unsigned
int*n*	cl_int*n*	32-bit signed
uint*n*	cl_uint*n*	32-bit unsigned
long*n*	cl_long*n*	64-bit signed
ulong*n*	cl_ulong*n*	64-bit unsigned
float*n*	cl_float*n*	32-bit float
double*n* OPTIONAL	cl_double*n*	64-bit float

Other Built-in Data Types [6.1.3]

The optional types listed here other than event_t are only defined if CL_DEVICE_IMAGE_SUPPORT is CL_TRUE.

OpenCL Type		Description
image2d_t	OPTIONAL	2D image handle
image3d_t	OPTIONAL	3D image handle
image2d_array_t	OPTIONAL	2D image array
image1d_t	OPTIONAL	1D image handle
image1d_buffer_t	OPTIONAL	1D image buffer
image1d_array_t	OPTIONAL	1D image array
sampler_t	OPTIONAL	sampler handle
event_t		event handle

Reserved Data Types [6.1.4]

OpenCL Type	Description
bool*n*	boolean vector
half*n*	16-bit, vector
quad, quad*n*	128-bit float, vector
complex half, complex half*n* imaginary half, imaginary half*n*	16-bit complex, vector
complex float, complex float*n* imaginary float, imaginary float*n*	32-bit complex, vector
complex double, complex double*n* imaginary double, imaginary double*n*	64-bit complex, vector
complex quad, complex quad*n* imaginary quad, imaginary quad*n*	128-bit complex, vector
float*n*x*m*	*n***m* matrix of 32-bit floats
double*n*x*m*	*n***m* matrix of 64-bit floats

Vector Component Addressing [6.1.7]

Vector Components

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
float2 v;	v.x, v.s0	v.y, v.s1														
float3 v;	v.x, v.s0	v.y, v.s1	v.z, v.s2													
float4 v;	v.x, v.s0	v.y, v.s1	v.z, v.s2	v.w, v.s3												
float8 v;	v.s0	v.s1	v.s2	v.s3	v.s4	v.s5	v.s6	v.s7								
float16 v;	v.s0	v.s1	v.s2	v.s3	v.s4	v.s5	v.s6	v.s7	v.s8	v.s9	v.sa, v.sA	v.sb, v.sB	v.sc, v.sC	v.sd, v.sD	v.se, v.sE	v.sf, v.sF

Vector Addressing Equivalences

Numeric indices are preceded by the letter s or S, e.g.: s1. Swizzling, duplication, and nesting are allowed, e.g.: v.yx, v.xx, v.lo.x

	v.lo	v.hi	v.odd	v.even
float2	v.x, v.s0	v.y, v.s1	v.y, v.s1	v.x, v.s0
float3 *	v.s01, v.xy	v.s23, v.zw	v.s13, v.yw	v.s02, v.xz
float4	v.s01, v.xy	v.s23, v.zw	v.s13, v.yw	v.s02, v.xz

	v.lo	v.hi	v.odd	v.even
float8	v.s0123	v.s4567	v.s1357	v.s0246
float16	v.s01234567	v.s89abcdef	v.s13579bdf	v.s02468ace

*When using .lo or .hi with a 3-component vector, the .w component is undefined.

Operators and Qualifiers

Operators [6.3]

These operators behave similarly as in C99 except that operands may include vector types when possible:

```
+    -    *    %    /    --    ++    ==    !=    &
~    ^    >    <    >=   <=    |     !     &&    ||
?:   >>   <<   =    ,    op=   sizeof
```

Address Space Qualifiers [6.5]

__global, global __local, local
__constant, constant __private, private

Function Qualifiers [6.7]

__kernel, kernel
__attribute__((vec_type_hint(*type*))) *//type defaults to int*
__attribute__((work_group_size_hint(*X*, *Y*, *Z*)))
__attribute__((reqd_work_group_size(*X*, *Y*, *Z*)))

Specify Type Attributes [6.11.1]

Use to specify special attributes of enum, struct and union types.

__attribute__((aligned(*n*)))
__attribute__((aligned))
__attribute__((packed))
__attribute__((endian(host)))
__attribute__((endian(device)))
__attribute__((endian))

Math Constants [6.12.2] [9.5.2]

The values of the following symbolic constants are type float, accurate within the precision of a single precision floating-point number.

MAXFLOAT	Value of maximum non-infinite single-precision floating-point number.
HUGE_VALF	Positive float expression, evaluates to +infinity.
HUGE_VAL	Positive double expression, evals. to +infinity. OPTIONAL

INFINITY	Constant float expression, positive or unsigned infinity.
NAN	Constant float expression, quiet NaN.

When double is supported, macros ending in _F are available in type double by removing _F from the macro name, and in type half when the half extension is enabled by replacing _F with _H.

M_E_F	Value of e
M_LOG2E_F	Value of $\log_2 e$
M_LOG10E_F	Value of $\log_{10} e$

M_LN2_F	Value of $\log_e 2$
M_LN10_F	Value of $\log_e 10$
M_PI_F	Value of π
M_PI_2_F	Value of π / 2
M_PI_4_F	Value of π / 4
M_1_PI_F	Value of 1 / π
M_2_PI_F	Value of 2 / π
M_2_SQRTPI_F	Value of 2 / √π
M_SQRT2_F	Value of √2
M_SQRT1_2_F	Value of 1 / √2

Integer Built-in Functions [6.12.3]

T is type char, char*n*, uchar, uchar*n*, short, short*n*, ushort, ushort*n*, int, int*n*, uint, uint*n*, long, long*n*, ulong, or ulong*n*, where *n* is 2, 3, 4, 8, or 16. ***Tu*** is the unsigned version of ***T***. ***Tsc*** is the scalar version of ***T***.

Tu **abs** (*T x*)	| *x* |
Tu **abs_diff** (*T x*, *T y*)	| *x* – *y* | without modulo overflow
T **add_sat** (*T x*, *T y*)	*x* + *y* and saturates the result
T **hadd** (*T x*, *T y*)	(*x* + *y*) >> 1 without mod. overflow
T **rhadd** (*T x*, *T y*)	(*x* + *y* + 1) >> 1
T **clamp** (*T x*, *T min*, *T max*) *T* **clamp** (*T x*, *Tsc min*, *Tsc max*)	min(max(*x*, *minval*), *maxval*)
T **clz** (*T x*)	number of leading 0-bits in *x*
T **mad_hi** (*T a*, *T b*, *T c*)	mul_hi(*a*, *b*) + *c*
T **mad_sat** (*T a*, *T b*, *T c*)	*a* * *b* + *c* and saturates the result
T **max** (*T x*, *T y*) *T* **max** (*T x*, *Tsc y*)	*y* if *x* < *y*, otherwise it returns *x*
T **min** (*T x*, *T y*)	*y* if *y* < *x*, otherwise it returns *x*
T **min** (*T x*, *Tsc y*)	*y* if *y* < *x*, otherwise it returns *x*
T **mul_hi** (*T x*, *T y*)	high half of the product of *x* and *y*
T **rotate** (*T v*, *T i*)	result[*indx*] = *v*[*indx*] << *i*[*indx*]
T **sub_sat** (*T x*, *T y*)	*x* - *y* and saturates the result
T **popcount** (*T x*)	Number of non-zero bits in *x*

*For **upsample**, return type is scalar when the parameters are scalar.*

short[*n*] **upsample** (char[*n*] *hi*, uchar[*n*] *lo*)	result[*i*]= ((short)*hi*[*i*]<< 8) | *lo*[*i*]
ushort[*n*] **upsample** (uchar[*n*] *hi*, uchar[*n*] *lo*)	result[*i*]=((ushort)*hi*[*i*]<< 8) | *lo*[*i*]
int[*n*] **upsample** (short[*n*] *hi*, ushort[*n*] *lo*)	result[*i*]=((int)*hi*[*i*]<< 16) | *lo*[*i*]
uint[*n*] **upsample** (ushort[*n*] *hi*, ushort[*n*] *lo*)	result[*i*]=((uint)*hi*[*i*]<< 16) | *lo*[*i*]
long[*n*] **upsample** (int[*n*] *hi*, uint[*n*] *lo*)	result[*i*]=((long)*hi*[*i*]<< 32) | *lo*[*i*]
ulong[*n*] **upsample** (uint[*n*] *hi*, uint[*n*] *lo*)	result[*i*]=((ulong)*hi*[*i*]<< 32) | *lo*[*i*]

The following fast integer functions optimize the performance of kernels. In these functions, ***T*** is type int, uint, int*n* or int*n*,where *n* is 2, 3, 4, 8, or 16.

T **mad24** (*T x*, *T y*, *T z*)	Multiply 24-bit integer values *x*, *y*, add 32-bit int. result to 32-bit int. *z*
T **mul24** (*T x*, *T y*)	Multiply 24-bit integer values *x* and *y*

Preprocessor Directives & Macros [6.10]

#pragma OPENCL FP_CONTRACT *on-off-switch* *on-off-switch:* ON, OFF, DEFAULT
#pragma OPENCL EXTENSION *extensionname* : *behavior*
#pragma OPENCL EXTENSION **all** : *behavior*

__FILE__	Current source file
__func__	Current function name

__LINE__	Integer line number
__OPENCL_VERSION__	Integer version number, e.g: 120
CL_VERSION_1_0	Substitutes integer 100 for 1.0
CL_VERSION_1_1	Substitutes integer 110 for 1.1
CL_VERSION_1_2	Substitutes integer 120 for 1.2
__OPENCL_C_VERSION__	Sub. integer for OpenCL C version.
__ENDIAN_LITTLE__	1 if device is little endian
__IMAGE_SUPPORT__	1 if images are supported

__FAST_RELAXED_MATH__	1 if –cl-fast-relaxed-math optimization option is specified
FP_FAST_FMA	Defined if double **fma** is fast
FP_FAST_FMAF	Defined if float **fma** is fast
FP_FAST_FMA_HALF	Defined if half **fma** is fast

```
__kernel_exec(X, typen)      Same as:
        __kernel __attribute__((work_group_size_hint(X, 1, 1)))
        __attribute__((vec_type_hint(typen)))
```

Math Built-in Functions [6.12.2] [9.5.2]

Ts is type float, optionally double, or half if the half extension is enabled. ***Tn*** is the vector form of ***Ts***, where *n* is 2, 3, 4, 8, or 16. ***T*** is ***Ts*** and ***Tn***. ***Q*** is qualifier __global, __local, or __private. **HN** indicates that half and native variants are available using only the float or float*n* types by prepending "half_" or "native_" to the function name. Prototypes shown in brown text are available in half_ and native_ forms only using the float or float*n* types.

T **acos** (*T*)	Arc cosine
T **acosh** (*T*)	Inverse hyperbolic cosine
T **acospi** (*T x*)	acos (*x*) / π
T **asin** (*T*)	Arc sine
T **asinh** (*T*)	Inverse hyperbolic sine
T **asinpi** (*T x*)	asin (*x*) / π
T **atan** (*T y_over_x*)	Arc tangent
T **atan2** (*T y*, *T x*)	Arc tangent of *y* / *x*
T **atanh** (*T*)	Hyperbolic arc tangent
T **atanpi** (*T x*)	atan (*x*) / π
T **atan2pi** (*T x*, *T y*)	atan2 (*y*, *x*) / π
T **cbrt** (*T*)	Cube root
T **ceil** (*T*)	Round to integer toward + infinity
T **copysign** (*T x*, *T y*)	*x* with sign changed to sign of *y*
T **cos** (*T*) **HN**	Cosine
T **cosh** (*T*)	Hyperbolic cosine
T **cospi** (*T x*)	cos (π *x*)
T **half_divide** (*T x*, *T y*) *T* **native_divide** (*T x*, *T y*)	*x* / *y* (*T* may only be float or float*n*)
T **erfc** (*T*)	Complementary error function
T **erf** (*T*)	Calculates error function of *T*
T **exp** (*T x*) **HN**	Exponential base e
T **exp2** (*T*) **HN**	Exponential base 2
T **exp10** (*T*) **HN**	Exponential base 10
T **expm1** (*T x*)	e^x -1.0
T **fabs** (*T*)	Absolute value
T **fdim** (*T x*, *T y*)	Positive difference between *x* and *y*
T **floor** (*T*)	Round to integer toward - infinity
T **fma** (*T a*, *T b*, *T c*)	Multiply and add, then round
T **fmax** (*T x*, *T y*) *Tn* **fmax** (*Tn x*, *Ts y*)	Return *y* if *x* < *y*, otherwise it returns *x*
T **fmin** (*T x*, *T y*) *Tn* **fmin** (*Tn x*, *Ts y*)	Return *y* if *y* < *x*, otherwise it returns *x*
T **fmod** (*T x*, *T y*)	Modulus. Returns *x* – *y* * trunc (*x*/*y*)
T **fract** (*T x*, *Q T* **iptr*)	Fractional value in *x*
Ts **frexp** (*T x*, *Q* int **exp*) *Tn* **frexp** (*T x*, *Q* int*n* **exp*)	Extract mantissa and exponent
T **hypot** (*T x*, *T y*)	Square root of $x^2 + y^2$
int[*n*] **ilogb** (*T x*)	Return exponent as an integer value
Ts **ldexp** (*T x*, int *n*) *Tn* **ldexp** (*T x*, int*n n*)	$x * 2^n$
T **lgamma** (*T x*) *Ts* **lgamma_r** (*T x*, *Q* int **signp*) *Tn* **lgamma_r** (*T x*, *Q* int*n* **signp*)	Log gamma function
T **log** (*T*) **HN**	Natural logarithm
T **log2** (*T*) **HN**	Base 2 logarithm
T **log10** (*T*) **HN**	Base 10 logarithm
T **log1p** (*T x*)	ln (1.0 + *x*)
T **logb** (*T x*)	Exponent of *x*
T **mad** (*T a*, *T b*, *T c*)	Approximates *a* * *b* + *c*
T **maxmag** (*T x*, *T y*)	Maximum magnitude of *x* and *y*
T **minmag** (*T x*, *T y*)	Minimum magnitude of *x* and *y*
T **modf** (*T x*, *Q T* **iptr*)	Decompose floating-point number
float[*n*] **nan** (uint[*n*] *nancode*) half[*n*] **nan** (ushort[*n*] *nancode*) double[*n*] **nan** (ulong[*n*] *nancode*)	Quiet NaN (Return is scalar when *nancode* is scalar)
T **nextafter** (*T x*, *T y*)	Next representable floating-point value after *x* in the direction of *y*
T **pow** (*T x*, *T y*)	Compute *x* to the power of *y*
Ts **pown** (*T x*, int *y*) *Tn* **pown** (*T x*, int*n y*)	Compute x^y, where *y* is an integer
T **powr** (*T x*, *T y*) **HN**	Compute x^y, where *x* is >= 0
T **half_recip** (*T x*) *T* **native_recip** (*T x*)	1 / *x* (*T* may only be float or float*n*)
T **remainder** (*T x*, *T y*)	Floating point remainder
Ts **remquo** (*T x*, *T y*, *Q* int **quo*) *Tn* **remquo** (*T x*, *T y*, *Q* int*n* **quo*)	Remainder and quotient
T **rint** (*T*)	Round to nearest even integer
Ts **rootn** (*T x*, int *y*) *Tn* **rootn** (*T x*, int*n y*)	Compute *x* to the power of 1/*y*
T **round** (*T x*)	Integral value nearest to *x* rounding
T **rsqrt** (*T*) **HN**	Inverse square root
T **sin** (*T*) **HN**	Sine
T **sincos** (*T x*, *Q T* **cosval*)	Sine and cosine of *x*
T **sinh** (*T*)	Hyperbolic sine
T **sinpi** (*T x*)	sin (π *x*)
T **sqrt** (*T*) **HN**	Square root
T **tan** (*T*) **HN**	Tangent
T **tanh** (*T*)	Hyperbolic tangent
T **tanpi** (*T x*)	tan (π *x*)
T **tgamma** (*T*)	Gamma function
T **trunc** (*T*)	Round to integer toward zero

Geometric Built-in Functions [6.12.5] [9.5.4]

Ts is scalar type float, optionally double, or half if the half extension is enabled. ***T*** is ***Ts*** and the 2-, 3-, or 4-component vector forms of ***Ts***.

float{3,4} **cross** (float{3,4} *p0*, float{3,4} *p1*) double{3,4} **cross** (double{3,4} *p0*, double{3,4} *p1*) half{3,4} **cross** (half{3,4} *p0*, half{3,4} *p1*)	Cross product
Ts **distance** (*T p0*, *T p1*)	Vector distance
Ts **dot** (*T p0*, *T p1*)	Dot product
Ts **length** (*T p*)	Vector length
T **normalize** (*T p*)	Normal vector length 1
float **fast_distance** (float *p0*, float *p1*) float **fast_distance** (float*n p0*, float*n p1*)	Vector distance
float **fast_length** (float *p*) float **fast_length** (float*n p*)	Vector length
float **fast_normalize** (float *p*) float*n* **fast_normalize** (float*n p*)	Normal vector length 1

Vector Data Load/Store [6.12.7] [9.5.6]

T is type char, uchar, short, ushort, int, uint, long, ulong, or float, optionally double, or half if the half extension is enabled. ***Tn*** refers to the vector form of type ***T***, where *n* is 2, 3, 4, 8, or 16. ***Q*** is an Address Space Qualifier listed in 6.5 unless otherwise noted. When red, ***Q*** cannot be __constant. ***R*** defaults to the current rounding mode, or is one of the Rounding Modes listed in 6.2.3.2.

Tn **vload*n*** (size_t *offset*, const *Q T* **p*)	Read vector data from address (*p* + (*offset* * *n*))
void **vstore*n*** (*Tn data*, size_t *offset*, *Q T* **p*)	Write vector data to address (*p* + (*offset* * *n*)
float **vload_half** (size_t *offset*, const *Q* half **p*)	Read a half from address (*p* + *offset*)
float*n* **vload_half*n*** (size_t *offset*, const *Q* half **p*)	Read a half*n* from address (*p* + (*offset* * *n*))
void **vstore_half** (float *data*, size_t *offset*, *Q* half **p*) void **vstore_half**_*R* (float *data*, size_t *offset*, *Q* half **p*) void **vstore_half** (double *data*, size_t *offset*, *Q* half **p*)	Write a half to address (*p* + *offset*)
void **vstore_half**_*R* (double *data*, size_t *offset*, *Q* half **p*)	Write a half to address (*p* + *offset*)
void **vstore_half*n*** (float*n data*, size_t *offset*, *Q* half **p*) void **vstore_half*n***_*R* (float*n data*, size_t *offset*, *Q* half **p*) void **vstore_half*n*** (double*n data*, size_t *offset*, *Q* half **p*) void **vstore_half*n***_*R* (double*n* *data*, size_t *offset*, *Q* half **p*)	Write a half vector to address (*p* + (*offset* * *n*))
float*n* **vloada_half*n*** (size_t *offset*, const *Q* half **p*)	Read half vector data from (*p* + (*offset* * *n*)). For half3, read from (*p* + (*offset* * 4)).
void **vstorea_half*n*** (float*n data*, size_t *offset*, *Q* half **p*) void **vstorea_half*n***_*R* (float*n data*, size_t *offset*, *Q* half **p*) void **vstorea_half*n*** (double*n data*, size_t *offset*, *Q* half **p*) void **vstorea_half*n***_*R* (double*n data*, size_t *offset*, *Q* half **p*)	Write half vector data to (*p* + (*offset* * *n*)). For half3, write to (*p* + (*offset* * 4)).

Async Copies and Prefetch Functions [6.12.10] [9.5.7]

T is type char, char*n*, uchar, uchar*n*, short, short*n*, ushort, ushort*n*, int, int*n*, uint, uint*n*, long, long*n*, ulong, ulong*n*, float, float*n*, optionally double or double*n*, or half or half*n* if the half extension is enabled.

event_t **async_work_group_copy** (__local *T* **dst*, const __global *T* **src*, size_t *num_gentypes*, event_t *event*) event_t **async_work_group_copy** (__global *T* **dst*, const __local *T* **src*, size_t *num_gentypes*, event_t *event*)	Copies *num_gentypes T* elements from *src* to *dst*
event_t **async_work_group_strided_copy** (__local *T* **dst*, const __global *T* **src*, size_t *num_gentypes*, size_t *src_stride*, event_t *event*) event_t **async_work_group_strided_copy** (__global *T* **dst*, const __local *T* **src*, size_t *num_gentypes*, size_t *dst_stride*, event_t *event*)	Copies *num_gentypes T* elements from *src* to *dst*
void **wait_group_events** (int *num_events*, event_t **event_list*)	Wait for events that identify the **async_work_group_copy** operations to complete
void **prefetch** (const __global *T* **p*, size_t *num_gentypes*)	Prefetch *num_gentypes* * sizeof(*T*) bytes into the global cache

Work-Item Built-in Functions [6.12.1]

These functions query the number of dimensions, the global and local work size specified to **clEnqueueNDRangeKernel**, and the global and local identifier of each work-item when this kernel is executed on a device. *D* is the dimension index.

uint **get_work_dim** ()	Number of dimensions in use
size_t **get_global_size** (uint *D*)	Number of global work-items
size_t **get_global_id** (uint *D*)	Global work-item ID value
size_t **get_local_size** (uint *D*)	Number of local work-items
size_t **get_local_id** (uint *D*)	Local work-item ID
size_t **get_num_groups** (uint *D*)	Number of work-groups
size_t **get_group_id** (uint *D*)	Returns the work-group ID
size_t **get_global_offset** (uint *D*)	Returns global offset

Common Built-in Functions [6.12.4] [9.5.3]

These functions operate component-wise and use round to nearest even rounding mode. ***Ts*** is type float, optionally double, or half if the half extension is enabled. ***Tn*** is the vector form of ***Ts***, where *n* is 2, 3, 4, 8, or 16. ***T*** is ***Ts*** and ***Tn***.

T **clamp** (*T x, T min, T max*) *Tn* **clamp** (*Tn x, Ts min, Ts max*)	Clamp *x* to range given by *min, max*
T **degrees** (*T radians*)	*radians* to degrees
T **max** (*T x, T y*) *Tn* **max** (*Tn x, Ts y*)	Max of *x* and *y*
T **min** (*T x, T y*) *Tn* **min** (*Tn x, Ts y*)	Min of *x* and *y*
T **mix** (*T x, T y, T a*) *Tn* **mix** (*Tn x, Tn y, Ts a*)	Linear blend of *x* and *y*
T **radians** (*T degrees*)	*degrees* to radians
T **step** (*T edge, T x*) *Tn* **step** (*Ts edge, Tn x*)	0.0 if *x* < *edge*, else 1.0
T **smoothstep** (*T edge0, T edge1, T x*) *T* **smoothstep** (*Ts edge0, Ts edge1, T x*)	Step and interpolate
T **sign** (*T x*)	Sign of *x*

Relational Built-in Functions [6.12.6]

These functions can be used with built-in scalar or vector types as arguments and return a scalar or vector integer result. ***T*** is type float, floatn, char, charn, uchar, ucharn, short, short*n*, ushort, ushort*n*, int, int*n*, uint, uint*n*, long, long*n*, ulong, ulong*n*, or optionally double or double*n*. ***Ti*** is type char, char*n*, short, short*n*, int, int*n*, long, or long*n*. ***Tu*** is type uchar, uchar*n*, ushort, ushort*n*, uint, uint*n*, ulong, or ulong*n*. *n* is 2, 3, 4, 8, or 16. Optional extension enables half and half*n* types.

int **isequal** (float *x*, float *y*) int*n* **isequal** (float*n x*, float*n y*) int **isequal** (double *x*, double *y*) long*n* **isequal** (double*n x*, double*n y*) int **isequal** (half *x*, half *y*) short*n* **isequal** (half*n x*, half*n y*)	Compare of *x* == *y*
int **isnotequal** (float *x*, float *y*) int*n* **isnotequal** (float*n x*, float*n y*) int **isnotequal** (double *x*, double *y*) long*n* **isnotequal** (double*n x*, double*n y*) int **isnotequal** (half *x*, half *y*) short*n* **isnotequal** (half*n x*, half*n y*)	Compare of *x* != *y*
int **isgreater** (float *x*, float *y*) int*n* **isgreater** (float*n x*, float*n y*) int **isgreater** (double *x*, double *y*) long*n* **isgreater** (double*n x*, double*n y*) int **isgreater** (half *x*, half *y*) short*n* **isgreater** (half*n x*, half*n y*)	Compare of *x* > *y*
int **isgreaterequal** (float *x*, float *y*) int*n* **isgreaterequal** (float*n x*, float*n y*) int **isgreaterequal** (double *x*, double *y*) long*n* **isgreaterequal** (double*n x*, double*n y*) int **isgreaterequal** (half *x*, half *y*) short*n* **isgreaterequal** (half*n x*, half*n y*)	Compare of *x* >= *y*
int **isless** (float *x*, float *y*) int*n* **isless** (float*n x*, float*n y*) int **isless** (double *x*, double *y*) long*n* **isless** (double*n x*, double*n y*) int **isless** (half *x*, half *y*) short*n* **isless** (half*n x*, half*n y*)	Compare of *x* < *y*
int **islessequal** (float *x*, float *y*) int*n* **islessequal** (float*n x*, float*n y*) int **islessequal** (double *x*, double *y*) long*n* **islessequal** (double*n x*, double*n y*) int **islessequal** (half *x*, half *y*) short*n* **islessequal** (half*n x*, half*n y*)	Compare of *x* <= *y*
int **islessgreater** (float *x*, float *y*) int*n* **islessgreater** (float*n x*, float*n y*) int **islessgreater** (double *x*, double *y*) long*n* **islessgreater** (double*n x*, double*n y*) int **islessgreater** (half *x*, half *y*) short*n* **islessgreater** (half*n x*, half*n y*)	Compare of (*x* < *y*) || (*x* > *y*)
int **isfinite** (float) int*n* **isfinite** (float*n*) int **isfinite** (double) long*n* **isfinite** (double*n*) int **isfinite** (half) short*n* **isfinite** (half*n*)	Test for finite value
int **isinf** (float) int*n* **isinf** (float*n*) int **isinf** (double) long*n* **isinf** (double*n*) int **isinf** (half) short*n* **isinf** (half*n*)	Test for + or – infinity
int **isnan** (float) int*n* **isnan** (float*n*) int **isnan** (double) long*n* **isnan** (double*n*) int **isnan** (half) short*n* **isnan** (half*n*)	Test for a NaN
int **isnormal** (float) int*n* **isnormal** (float*n*) int **isnormal** (double)	Test for a normal value
long*n* **isnormal** (double*n*) int **isnormal** (half) short*n* **isnormal** (half*n*)	Test for a normal value
int **isordered** (float *x*, float *y*) int*n* **isordered** (float*n x*, float*n y*) int **isordered** (double *x*, double *y*) long*n* **isordered** (double*n x*, double*n y*) int **isordered** (half *x*, half *y*) short*n* **isordered** (half*n x*, half*n y*)	Test if arguments are ordered
int **isunordered** (float *x*, float *y*) int*n* **isunordered** (float*n x*, float*n y*) int **isunordered** (double *x*, double *y*) long*n* **isunordered** (double*n x*, double*n y*) int **isunordered** (half *x*, half *y*) short*n* **isunordered** (half*n x*, half*n y*)	Test if arguments are unordered
int **signbit** (float) int*n* **signbit** (float*n*) int **signbit** (double) long*n* **signbit** (double*n*) int **signbit** (half) short*n* **signbit** (half*n*)	Test for sign bit
int **any** (*Ti x*)	1 if MSB in component of *x* is set; else 0
int **all** (*Ti x*)	1 if MSB in all components of *x* are set; else 0
T **bitselect** (*T a, T b, T c*) half **bitselect** (half *a*, half *b*, half *c*) half*n* **bitselect** (half*n a*, half*n b*, half*n c*)	Each bit of result is corresponding bit of *a* if corresponding bit of *c* is 0
T **select** (*T a, T b, Ti c*) *T* **select** (*T a, T b, Tu c*) half*n* **select** (half*n a*, half*n b*, short*n c*) half **select** (half *a*, half *b*, short *c*) half*n* **select** (half*n a*, half*n b*, ushort*n c*) half **select** (half *a*, half *b*, ushort *c*)	For each component of a vector type, result[*i*] = if MSB of *c*[*i*] is set ? *b*[*i*] : *a*[*i*] For scalar type, result = *c* ? *b* : *a*

Atomic Functions [6.12.11] [9.3]

These functions functions provide atomic operations on 32-bit signed and unsigned integers and single precision floating-point to locations in __global or __local memory. ***T*** is type int or unsigned int. ***T*** may also be type float for **atomic_xchg**, and type long or ulong for extended 64-bit atomic functions. ***Q*** is volatile __global or volatile __local.

T **atomic_add** (*Q T *p, T val*)	Read, add, and store
T **atomic_sub** (*Q T *p, T val*)	Read, subtract, and store
T **atomic_xchg** (*Q T *p, T val*)	Read, swap, and store
T **atomic_inc** (*Q T *p*)	Read, increment, and store
T **atomic_dec** (*Q T *p*)	Read, decrement, and store
T **atomic_cmpxchg** (*Q T *p, T cmp, T val*)	Read, store (**p* ==*cmp*) ? *val* : **p*
T **atomic_min** (*Q T *p, T val*)	Read, store min(**p, val*)
T **atomic_max** (*Q T *p, T val*)	Read, store max(**p, val*)
T **atomic_and** (*Q T *p, T val*)	Read, store (**p* & *val*)
T **atomic_or** (*Q T *p, T val*)	Read, store (**p* | *val*)
T **atomic_xor** (*Q T *p, T val*)	Read, store (**p* ^ *val*)

Optional extensions enable forms of these functions using the atom_ prefix that implement atomic operations on 64-bit signed and unsigned integers. To use any of these forms, include the following in the OpenCL program source:

#pragma OPENCL EXTENSION *extension-name* : enable

Use cl_khr_int64_base_atomics for *extension-name* to enable 64-bit versions of the following functions:

atom_add	atom_sub	atom_inc
atom_dec	atom_xchg	atom_cmpxchg

Use cl_khr_int64_extended_atomics for *extension-name* to enable 64-bit versions of the following functions:

atom_min	atom_max	atom_and
atom_or	atom_xor	

Conversions and Type Casting Examples [6.2]

T a = (*T*)*b*; // *Scalar to scalar, or scalar to vector*
T a = convert_*T*(*b*); *T a* = convert_*T*_*R*(*b*);
T a = as_*T*(*b*); *T a* = convert_*T*_sat_*R*(*b*);

R can be one of the following rounding modes:

_rte	to nearest even	_rtp	toward + infinity
_rtz	toward zero	_rtn	toward - infinity

Synchronization and Explicit Memory Fence Functions [6.12.8, 6.12.9]

flags argument is the memory address space, set to a combination of CLK_LOCAL_MEM_FENCE and CLK_GLOBAL_MEM_FENCE. Explicit memory fence functions provide ordering between memory operations of a work-item.

void **barrier** (cl_mem_fence_flags *flags*)	Work-items in a work-group must execute this before any can continue
void **mem_fence** (cl_mem_fence_flags *flags*)	Orders loads and stores of a work-item executing a kernel
void **read_mem_fence** (cl_mem_fence_flags *flags*)	Orders memory loads
void **write_mem_fence** (cl_mem_fence_flags *flags*)	Orders memory stores

Miscellaneous Vector Functions [6.12.12]

Tm and ***Tn*** are type char*n*, uchar*n*, short*n*, ushort*n*, int*n*, uint*n*, long*n*, ulong*n*, float*n*, optionally double*n*, or half*n* if the half extension is enabled, where *n* is 2,4,8, or 16 except in **vec_step** it may also be 3. ***TUn*** is uchar*n*, ushort*n*, uint*n*, or ulong*n*.

int **vec_step** (*Tn a*) int **vec_step** (*typename*)	Takes a built-in scalar or vector data type argument, returns an integer showing number of elements in the scalar or vector. Returns 1 for scalar, 4 for 3-component vector, else number of elements in the specified type.
Tn **shuffle** (*Tm x, TUn mask*) *Tn* **shuffle2** (*Tm x, Tm y, TUn mask*)	Construct permutation of elements from one or two input vectors, return a vector with same element type as input and length that is the same as the shuffle mask.

printf Function [6.12.13]

Writes output to an implementation-defined stream.

int **printf** (constant char * restrict *format*, ...)

printf output synchronization

When the event associated with a particular kernel invocation completes, the output of applicable printf() calls is flushed to the implementation-defined output stream.

printf format string

The format string follows C99 conventions and supports an optional vector specifier:

%[*flags*][*width*][.*precision*][*vector*][*length*]*conversion*

Examples:

The following examples show the use of the vector specifier in the **printf** format string.

```
float4  f = (float4)(1.0f, 2.0f, 3.0f, 4.0f);
printf("f4 = %2.2v4f\n", f);
```

Output: f4 = 1.00,2.00,3.00,4.00

```
uchar4 uc = (uchar4)(0xFA, 0xFB, 0xFC, 0xFD);
printf("uc = %#v4x\n", uc);
```

Output: uc = 0xfa,0xfb,0xfc,0xfd

```
uint2 ui = (uint2)(0x12345678, 0x87654321);
printf("unsigned short value = (%#v2hx)\n", ui);
```

Output: unsigned short value = (0x5678,0x4321)

OpenCL Image Processing:

Following is a subset of the OpenCL specification that pertains to image processing and graphics.

Image Objects

Create Image Objects [5.3.1]

cl_mem **clCreateImage** (cl_context *context*,
  cl_mem_flags *flags*,
  const cl_image_format **image_format*,
  const cl_image_desc **image_desc*,
  void **host_ptr*, cl_int **errcode_ret*)

flags:
  CL_MEM_READ_WRITE,
  CL_MEM_{WRITE, READ}_ONLY,
  CL_MEM_HOST_{WRITE, READ}_ONLY,
  CL_MEM_HOST_NO_ACCESS,
  CL_MEM_{USE, ALLOC, COPY}_HOST_PTR

Query List of Supported Image Formats [5.3.2]

cl_int **clGetSupportedImageFormats** (
  cl_context *context*, cl_mem_flags *flags*,
  cl_mem_object_type *image_type*,
  cl_uint *num_entries*, cl_image_format **image_formats*,
  cl_uint **num_image_formats*)

flags: See **clCreateImage**

image_type: CL_MEM_OBJECT_IMAGE{1D, 2D, 3D},
  CL_MEM_OBJECT_IMAGE1D_BUFFER,
  CL_MEM_OBJECT_IMAGE{1D, 2D}_ARRAY

Read, Write, Copy Image Objects [5.3.3]

cl_int **clEnqueueReadImage** (
  cl_command_queue *command_queue*,
  cl_mem *image*, cl_bool *blocking_read*,
  const size_t **origin*, const size_t **region*,
  size_t *row_pitch*, size_t *slice_pitch*, void **ptr*,
  cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueWriteImage** (
  cl_command_queue *command_queue*,
  cl_mem *image*, cl_bool *blocking_write*,
  const size_t **origin*, const size_t **region*,
  size_t *input_row_pitch*, size_t *input_slice_pitch*,
  const void **ptr*, cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueFillImage** (
  cl_command_queue *command_queue*,
  cl_mem *image*, const void **fill_color*,
  const size_t **origin*, const size_t **region*,
  cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*,
  cl_event **event*)

cl_int **clEnqueueCopyImage** (
  cl_command_queue *command_queue*,
  cl_mem *src_image*, cl_mem *dst_image*,
  const size_t **src_origin*, const size_t **dst_origin*,
  const size_t **region*, cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

Copy Between Image, Buffer Objects [5.3.4]

cl_int **clEnqueueCopyImageToBuffer** (
  cl_command_queue *command_queue*,
  cl_mem *src_image*, cl_mem *dst_buffer*,
  const size_t **src_origin*, const size_t **region*,
  size_t *dst_offset*, cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

cl_int **clEnqueueCopyBufferToImage** (
  cl_command_queue *command_queue*,
  cl_mem *src_buffer*, cl_mem *dst_image*,
  size_t *src_offset*,
  const size_t **dst_origin*, const size_t **region*,
  cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*)

Map and Unmap Image Objects [5.3.5]

void * **clEnqueueMapImage** (
  cl_command_queue *command_queue*, cl_mem *image*,
  cl_bool *blocking_map*, cl_map_flags *map_flags*,
  const size_t **origin*, const size_t **region*,
  size_t **image_row_pitch*, size_t **image_slice_pitch*,
  cl_uint *num_events_in_wait_list*,
  const cl_event **event_wait_list*, cl_event **event*,
  cl_int **errcode_ret*)

Also see **clGetMemObjectInfo** [5.4.5]

Query Image Objects [5.3.6]

cl_int **clGetImageInfo** (cl_mem *image*,
  cl_image_info *param_name*, size_t *param_value_size*,
  void **param_value*, size_t **param_value_size_ret*)

param_name: CL_IMAGE_{ARRAY, ELEMENT}_SIZE,
  CL_IMAGE_{ROW, SLICE}_PITCH,
  CL_IMAGE_{FORMAT, BUFFER, HEIGHT, WIDTH, DEPTH},
  CL_IMAGE_NUM_{SAMPLES, MIP_LEVELS},
  CL_IMAGE_DX9_MEDIA_PLANE_KHR,
  CL_IMAGE_{D3D10, D3D11}_SUBRESOURCE_KHR

Image Formats [5.3.1.1, 9.5]

Supported image formats: image_channel_order with image_channel_data_type.

Built-in support: [Table 5.8]

CL_RGBA: CL_HALF_FLOAT, CL_FLOAT, CL_UNORM_INT{8,16}, CL_SIGNED_INT{8,16,32}, CL_UNSIGNED_INT{8,16,32}
CL_BGRA: CL_UNORM_INT8

Optional support: [Table 5.6]

CL_R, **CL_A**: CL_HALF_FLOAT, CL_FLOAT, CL_UNORM_INT{8,16}, CL_SIGNED_INT{8,16,32}, CL_UNSIGNED_INT{8,16,32}, CL_SNORM_INT{8,16}
CL_INTENSITY: CL_HALF_FLOAT, CL_FLOAT, CL_UNORM_INT{8,16}, CL_SNORM_INT{8|16}
CL_LUMINANCE: CL_UNORM_INT{8,16}, CL_HALF_FLOAT, CL_FLOAT, CL_SNORM_INT{8,16}
CL_RG, **CL_RA**: CL_HALF_FLOAT, CL_FLOAT, CL_UNORM_INT{8,16}, CL_SIGNED_INT{8,16, 32}, CL_UNSIGNED_INT{8,16,32}, CL_SNORM_INT{8,16}
CL_RGB: CL_UNORM_SHORT_{555,565}, CL_UNORM_INT_101010
CL_ARGB: CL_UNORM_INT8, CL_SIGNED_INT8, CL_UNSIGNED_INT8, CL_SNORM_INT8
CL_BGRA: CL_{SIGNED, UNSIGNED}_INT8, CL_SNORM_INT8

Image Read and Write Built-in Functions

[6.12.14] [9.4, 9.5.8]

The built-in functions defined in this section can only be used with image memory objects created with **clCreateImage**. *sampler* specifies the addressing and filtering mode to use. To enable the **read_imageh** and **write_imageh** forms, enable the extension cl_khr_fp16. To enable the type image3d_t in functions **write_image{f, i, ui, h}**, enable the extension cl_khr_3d_image_writes.

Read and write functions for 1D images

Read an element from a 1D image, or write a color value to a location in a 1D image.

float4 **read_imagef** (image1d_t *image*, sampler_t *sampler*,
  {int, float} *coord*)
float4 **read_imagef** (image1d_t *image*, int *coord*)
float4 **read_imagef** (image1d_array_t *image*,
  sampler_t *sampler*, {int2, float4} *coord*)
float4 **read_imagef** (image1d_array_t *image*, int2 *coord*)
float4 **read_imagef** (image1d_buffer_t *image*, int *coord*)

int4 **read_imagei** (image1d_t *image*, sampler_t *sampler*,
  {int, float} *coord*)
int4 **read_imagei** (image1d_t *image*, int *coord*)
int4 **read_imagei** (image1d_array_t *image*, sampler_t *sampler*,
  {int2, float2} *coord*)
int4 **read_imagei** (image1d_array_t *image*, int2 *coord*)
int4 **read_imagei** (image1d_buffer_t *image*, int *coord*)

uint4 **read_imageui** (image1d_t *image*, sampler_t *sampler*,
  {int, float} *coord*)
uint4 **read_imageui** (image1d_t *image*, int *coord*)
uint4 **read_imageui** (image1d_array_t *image*,
  sampler_t *sampler*, {int2, float2} *coord*)
uint4 **read_imageui** (image1d_array_t *image*, int2 *coord*)
uint4 **read_imageui** (image1d_buffer_t *image*, int *coord*)

half4 **read_imageh** (image1d_t *image*, sampler_t *sampler*,
  {int, float} *coord*)
half4 **read_imageh** (image1d_t *image*, int *coord*)
half4 **read_imageh** (image1d_array_t *image*,
  sampler_t *sampler*, {int2, float4} *coord*)
half4 **read_imageh** (image1d_array_t *image*, int2 *coord*)
half4 **read_imageh** (image1d_buffer_t *image*, int *coord*)

void **write_imagef** (image1d_t *image*, int *coord*, float4 *color*)
void **write_imagef** (image1d_array_t *image*, int2 *coord*,
  float4 *color*)
void **write_imagef** (image1d_buffer_t *image*, int *coord*,
  float4 *color*)

Read and write functions for 1D images (continued)

void **write_imagei** (image1d_t *image*, int *coord*, int4 *color*)
void **write_imagei** (image1d_array_t *image*, int2 *coord*,
  int4 *color*)
void **write_imagei** (image1d_buffer_t *image*, int *coord*,
  int4 *color*)

void **write_imageh** (image1d_t *image*, int *coord*, half4 *color*)
void **write_imageh** (image1d_array_t *image*, int2 *coord*,
  half4 *color*)
void **write_imageh** (image1d_buffer_t *image*, int *coord*,
  half4 *color*)

void **write_imageui** (image1d_t *image*, int *coord*, uint4 *color*)
void **write_imageui** (image1d_array_t *image*, int2 *coord*,
  uint4 *color*)
void **write_imageui** (image1d_buffer_t *image*, int *coord*,
  uint4 *color*)

Read and write functions for 2D images

Read an element from a 2D image, or write a color value to a location in a 2D image.

float4 **read_imagef** (image2d_t *image*, sampler_t *sampler*,
  {int2, float2} *coord*)
float4 **read_imagef** (image2d_t *image*, int2 *coord*)
float4 **read_imagef** (image2d_array_t *image*,
  sampler_t *sampler*, {int4, float4} *coord*)
float4 **read_imagef** (image2d_array_t *image*, int4 *coord*)

int4 **read_imagei** (image2d_t *image*, sampler_t *sampler*,
  {int2, float2} *coord*)
int4 **read_imagei** (image2d_t *image*, int2 *coord*)
int4 **read_imagei** (image2d_array_t *image*, sampler_t *sampler*,
  {int4, float4} *coord*)
int4 **read_imagei** (image2d_array_t *image*, int4 *coord*)

uint4 **read_imageui** (image2d_t *image*, sampler_t *sampler*,
  {int2, float2} *coord*)
uint4 **read_imageui** (image2d_t *image*, int2 *coord*)
uint4 **read_imageui** (image2d_array_t *image*,
  sampler_t *sampler*, {int4, float4} *coord*)
uint4 **read_imageui** (image2d_array_t *image*, int4 *coord*)

half4 **read_imageh** (image2d_t *image*, sampler_t *sampler*,
  {int2, float2} *coord*)
half4 **read_imageh** (image2d_t *image*, int2 *coord*)
half4 **read_imageh** (image2d_array_t *image*,
  sampler_t *sampler*, {int4, float4} *coord*)
half4 **read_imageh** (image2d_array_t *image*, int4 *coord*)

Read and write functions for 2D images (continued)

void **write_imagef** (image2d_t *image*, int2 *coord*, float4 *color*)
void **write_imagef** (image2d_array_t *image*, int4 *coord*,
  float4 *color*)

void **write_imagei** (image2d_t *image*, int2 *coord*, int4 *color*)
void **write_imagei** (image2d_array_t *image*, int4 *coord*,
  int4 *color*)

void **write_imageui** (image2d_t *image*, int2 *coord*,
  uint4 *color*)
void **write_imageui** (image2d_array_t *image*, int4 *coord*,
  uint4 *color*)

void **write_imageh** (image2d_t *image*, int2 *coord*, half4 *color*)
void **write_imageh** (image2d_array_t *image*, int4 *coord*,
  half4 *color*)

Read and write functions for 3D images

Read an element from a 3D image, or write a color value to a location in a 3D image.

float4 **read_imagef** (image3d_t *image*, sampler_t *sampler*,
  {int4, float4} *coord*)
float4 **read_imagef** (image3d_t *image*, int4 *coord*)

int4 **read_imagei** (image3d_t *image*, sampler_t *sampler*,
  {int4, float4} *coord*)
int4 **read_imagei** (image3d_t *image*, int4 *coord*)

uint4 **read_imageui** (image3d_t *image*, sampler_t *sampler*,
  {int4, float4} *coord*)
uint4 **read_imageui** (image3d_t *image*, int4 *coord*)

half4 **read_imageh** (image3d_t *image*, sampler_t *sampler*,
  {int4, float4} *coord*)
half4 **read_imageh** (image3d_t *image*, int4 *coord*)

Use this pragma to enable writes to type image3d_t:

#pragma OPENCL EXTENSION cl_khr_3d_image_writes : enable

void **write_imagef** (image3d_t *image*, int4 *coord*,
  float4 *color*)

void **write_imagei** (image3d_t *image*, int4 *coord*, int4 *color*)

void **write_imageui** (image3d_t *image*, int4 *coord*, uint4 *color*)

void **write_imageh** (image3d_t *image*, int4 *coord*, half4 *color*)

Access Qualifiers [6.6]

Apply to 2D and 3D image types to declare if the image memory object is being read or written by a kernel.

  __read_only, read_only
  __write_only, write_only

OpenCL Image Processing (continued):

Following is a subset of the OpenCL specification that pertains to image processing and graphics.

Sampler Objects [5.5]

```
cl_sampler clCreateSampler (
    cl_context context, cl_bool normalized_coords,
    cl_addressing_mode addressing_mode,
    cl_filter_mode filter_mode, cl_int *errcode_ret)
```

addressing_mode: CL_ADDRESS_[MIRRORED_]REPEAT, CL_ADDRESS_CLAMP[_TO_EDGE], CL_ADDRESS_NONE
filter_mode: CL_FILTER_{NEAREST, LINEAR}

```
cl_int clRetainSampler (cl_sampler sampler)

cl_int clReleaseSampler (cl_sampler sampler)

cl_int clGetSamplerInfo (cl_sampler sampler,
    cl_sampler_info param_name,
    size_t param_value_size, void *param_value,
    size_t *param_value_size_ret)
```

param_name: CL_SAMPLER_REFERENCE_COUNT, CL_SAMPLER_{CONTEXT, FILTER_MODE}, CL_SAMPLER_ADDRESSING_MODE, CL_SAMPLER_NORMALIZED_COORDS

Sampler Declaration Fields [6.12.14.1]

The sampler can be passed as an argument to the kernel using **clSetKernelArg**, or can be declared in the outermost scope of kernel functions, or it can be a constant variable of type sampler_t declared in the program source.

```
const sampler_t <sampler-name> =
    <normalized-mode> | <address-mode> | <filter-mode>
```

normalized-mode:
CLK_NORMALIZED_COORDS_{TRUE, FALSE}

address-mode:
CLK_ADDRESS_{REPEAT, CLAMP, NONE},
CLK_ADDRESS_{CLAMP_TO_EDGE, MIRRORED_REPEAT}

filter-mode: CLK_FILTER_NEAREST, CLK_FILTER_LINEAR

Direct3D 10 Sharing [9.9]

Provide interoperability between OpenCL and Direct3D 10. If supported, cl_khr_d3d10_sharing will be present in CL_PLATFORM_EXTENSIONS or CL_DEVICE_EXTENSIONS.

```
cl_int clGetDeviceIDsFromD3D10KHR (
    cl_platform_id platform,
    cl_d3d10_device_source_khr d3d_device_source,
    void *d3d_object,
    cl_d3d10_device_set_khr d3d_device_set,
    cl_uint num_entries, cl_device_id *devices,
    cl_uint *num_devices)
```

d3d_device_source: CL_D3D10_{DEVICE, DXGI_ADAPTER}_KHR
d3d_device_set: CL_{ALL, PREFERRED}_DEVICES_FOR_D3D10_KHR

```
cl_mem clCreateFromD3D10BufferKHR (
    cl_context context, cl_mem_flags flags,
    ID3D10Buffer *resource, cl_int *errcode_ret)
```

flags: CL_MEM_{READ, WRITE}_ONLY, CL_MEM_READ_WRITE

```
cl_mem clCreateFromD3D10Texture2DKHR (
    cl_context context, cl_mem_flags flags,
    ID3D10Texture2D *resource, UINT subresource,
    cl_int *errcode_ret)
```

flags: See **clCreateFromD3D10BufferKHR**

```
cl_mem clCreateFromD3D10Texture3DKHR (
    cl_context context, cl_mem_flags flags,
    ID3D10Texture3D *resource, UINT subresource,
    cl_int *errcode_ret)
```

flags: See **clCreateFromD3D10BufferKHR**

```
cl_int clEnqueueAcquireD3D10ObjectsKHR (
    cl_command_queue command_queue,
    cl_uint num_objects, const cl_mem *mem_objects,
    cl_uint num_events_in_wait_list,
    const cl_event *event_wait_list, cl_event *event)

cl_int clEnqueueReleaseD3D10ObjectsKHR (
    cl_command_queue command_queue,
    cl_uint num_objects, const cl_mem *mem_objects,
    cl_uint num_events_in_wait_list,
    const cl_event *event_wait_list, cl_event *event)
```

Image Query Functions [6.12.14.5]

Query image width, height, and depth in pixels

```
int get_image_width (image{1,2,3}d_t image)
int get_image_width (image1d_buffer_t image)
int get_image_width (image{1,2}d_array_t image)

int get_image_height (image{2,3}d_t image)
int get_image_height (image2d_array_t image)

int get_image_depth (image3d_t image)
```

Query image array size

```
size_t get_image_array_size (image1d_array_t image)
size_t get_image_array_size (image2d_array_t image)
```

Query image dimensions

```
int2 get_image_dim (image2d_t image)
int2 get_image_dim (image2d_array_t image)
int4 get_image_dim (image3d_t image)
```

Query image Channel data type and order

```
int get_image_channel_data_type (image{1,2,3}d_t image)
int get_image_channel_data_type (image1d_buffer_t image)
int get_image_channel_data_type (image{1,2}d_array_t image)

int get_image_channel_order (image{1,2,3}d_t image)
int get_image_channel_order (image1d_buffer_t image)
int get_image_channel_order (image{1,2}d_array_t image)
```

OpenGL Sharing

Functions available if cl_khr_gl_sharing or cl_apple_gl_sharing is supported. Creating OpenCL memory objects from OpenGL objects using **clCreateFromGLBuffer**, **clCreateFromGLTexture**, and **clCreateFromGLRenderbuffer** ensure the OpenGL object will not be deleted while the corresponding OpenCL memory object exists.

CL Buffer Objects > GL Buffer Objects [9.7.2]

```
cl_mem clCreateFromGLBuffer (cl_context context,
    cl_mem_flags flags, GLuint bufobj, cl_int *errcode_ret)
```

flags: CL_MEM_{READ, WRITE}_ONLY, CL_MEM_READ_WRITE

CL Image Objects > GL Textures [9.7.3]

```
cl_mem clCreateFromGLTexture (cl_context context,
    cl_mem_flags flags, GLenum texture_target,
    GLint miplevel, GLuint texture, cl_int *errcode_ret)
```

flags: See **clCreateFromGLBuffer**

texture_target: GL_TEXTURE_{1D, 2D}[_ARRAY], GL_TEXTURE_{3D, BUFFER, RECTANGLE}, GL_TEXTURE_CUBE_MAP_POSITIVE_{X, Y, Z}, GL_TEXTURE_CUBE_MAP_NEGATIVE_{X, Y, Z}

CL Image Objects > GL Renderbuffers [9.7.4]

```
cl_mem clCreateFromGLRenderbuffer (
    cl_context context, cl_mem_flags flags,
    GLuint renderbuffer, cl_int *errcode_ret)
```

flags: CL_MEM_{READ, WRITE}_ONLY, CL_MEM_READ_WRITE

Query Information [9.7.5]

```
cl_int clGetGLObjectInfo (cl_mem memobj,
    cl_gl_object_type *gl_object_type,
    GLuint *gl_object_name)
```

**gl_object_type* returns:
CL_GL_OBJECT_TEXTURE_BUFFER,
CL_GL_OBJECT_TEXTURE{1D, 2D, 3D},
CL_GL_OBJECT_TEXTURE{1D, 2D}_ARRAY,
CL_GL_OBJECT_{BUFFER, RENDERBUFFER}

```
cl_int clGetGLTextureInfo (cl_mem memobj,
    cl_gl_texture_info param_name,
    size_t param_value_size, void *param_value,
    size_t *param_value_size_ret)
```

param_name:
CL_GL_{TEXTURE_TARGET, MIPMAP_LEVEL}

Share Objects [9.7.6]

```
cl_int clEnqueueAcquireGLObjects (
    cl_command_queue command_queue,
    cl_uint num_objects, const cl_mem *mem_objects,
    cl_uint num_events_in_wait_list,
    const cl_event *event_wait_list, cl_event *event)

cl_int clEnqueueReleaseGLObjects (
    cl_command_queue command_queue,
    cl_uint num_objects, const cl_mem *mem_objects,
    cl_uint num_events_in_wait_list,
    const cl_event *event_wait_list, cl_event *event)
```

CL Event Objects > GL Sync Objects [9.8.2]

```
cl_event clCreateEventFromGLsyncKHR (
    cl_context context, GLsync sync, cl_int *errcode_ret)
```

CL Context > GL Context, Sharegroup [9.6.5]

```
cl_int clGetGLContextInfoKHR (
    const cl_context_properties *properties,
    cl_gl_context_info param_name, size_t param_value_size,
    void *param_value, size_t *param_value_size_ret)
```

param_name: CL_DEVICES_FOR_GL_CONTEXT_KHR, CL_CURRENT_DEVICE_FOR_GL_CONTEXT_KHR

DX9 Media Surface Sharing [9.10]

These functions allow applications to use media surfaces as OpenCL memory objects. If this extension in supported, cl_khr_dx9_media_sharing will be present in CL_PLATFORM_EXTENSIONS or CL_DEVICE_EXTENSIONS.

```
cl_int clGetDeviceIDsFromDX9MediaAdapterKHR (
    cl_platform_id platform, cl_uint num_media_adapters,
    cl_dx9_media_adapter_type_khr *media_adapters_type,
    void *media_adapters,
    cl_dx9_mem_adapter_set_khr media_adapter_set,
    cl_uint num_entries, cl_device_id *devices,
    cl_int *num_devices)
```

media_adapter_type: CL_ADAPTER_{D3D9, D3D9EX, DXVA}_KHR
media_adapter_set: CL_ALL_DEVICES_FOR_DXP_MEDIA_ADAPTER_KHR, CL_PREFERRED_DEVICES_FOR_DX9_MEDIA_ADAPTER_KHR

```
cl_mem clCreateFromDX9MediaSurfaceKHR (
    cl_context context, cl_mem_flags flags,
    cl_dx9_media_adapter_type_khr adapter_type,
    void *surface_info, cl_uint plane, cl_int *errcode_ret)
```

flags: CL_MEM_{READ, WRITE}_ONLY, CL_MEM_READ_WRITE
adapter_type: CL_ADAPTER_{D3D9, D3D9EX, DXVA}_KHR

```
cl_int clEnqueueAcquireDX9MediaSurfacesKHR (
    cl_command_queue command_queue,
    cl_uint num_objects, const cl_mem *mem_objects,
    cl_uint num_events_in_wait_list,
    const cl_event *event_wait_list, cl_event *event)

cl_int clEnqueueReleaseDX9MediaSurfacesKHR (
    cl_command_queue command_queue,
    cl_uint num_objects, const cl_mem *mem_objects,
    cl_uint num_events_in_wait_list,
    const cl_event *event_wait_list, cl_event *event)
```

Direct3D 11 Sharing [9.11]

Provide interoperability between OpenCL and Direct3D 11. If supported, cl_khr_d3d11_sharing will be present in CL_PLATFORM_EXTENSIONS or CL_DEVICE_EXTENSIONS.

```
cl_mem clCreateFromD3D11Texture2DKHR (
    cl_context context, cl_mem_flags flags,
    ID3D11Texture2D *resource,
    UINT subresource, cl_int *errcode_ret)
```

flags: CL_MEM_{READ, WRITE}_ONLY, CL_MEM_READ_WRITE

```
cl_int clGetDeviceIDsFromD3D11KHR (
    cl_platform_id platform,
    cl_d3d11_device_source_khr d3d_device_source,
    void *d3d_object,
    cl_d3d11_device_set_khr d3d_device_set,
    cl_uint num_entries, cl_device_id *devices,
    cl_uint *num_devices)
```

d3d_device_source: CL_D3D11_DEVICE_KHR, CL_D3D11_DXGI_ADAPTER_KHR
d3d_device_set: CL_PREFERRED_DEVICES_FOR_D3D11_KHR, CL_ALL_DEVICES_FOR_D3D11_KHR

```
cl_mem clCreateFromD3D11BufferKHR (
    cl_context context, cl_mem_flags flags,
    ID3D11Buffer *resource, cl_int *errcode_ret)
```

flags: CL_MEM_{READ, WRITE}_ONLY, CL_MEM_READ_WRITE

```
cl_mem clCreateFromD3D11Texture3DKHR (
    cl_context context, cl_mem_flags flags,
    ID3D11Texture3D *resource, UINT subresource,
    cl_int *errcode_ret)
```

flags: CL_MEM_{READ, WRITE}_ONLY, CL_MEM_READ_WRITE

```
cl_int clEnqueueAcquireD3D11ObjectsKHR (
    cl_command_queue command_queue,
    cl_uint num_objects, const cl_mem *mem_objects,
    cl_uint num_events_in_wait_list,
    const cl_event *event_wait_list, cl_event *event)

cl_int clEnqueueReleaseD3D11ObjectsKHR (
    cl_command_queue command_queue,
    cl_uint num_objects, const cl_mem *mem_objects,
    cl_uint num_events_in_wait_list,
    const cl_event *event_wait_list, cl_event *event)
```

OpenCL Reference Card Index

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OpenCL

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