



Figure 1: Object Dependency Graph

This document describes the plan and progress of the implementation of Vulkayes.

## Synchronization

Most parameters in Vulkan require external synchronization. Synchronization is provided in two flavours: Single-thread and multi-thread. Single-thread synchronization primitives are noops, while multi-thread primitives provide actual multi-thread and multi-core synchronization. If single-thread synchronization is chosen, the Rust type system statically prevents use in multiple threads.

### Externally Synchronized Parameters

- The `instance` parameter in `vkDestroyInstance`
  - [Consequence of shared pointer usage](#)
- The `device` parameter in `vkDestroyDevice`
  - [Consequence of shared pointer usage](#)
- The `queue` parameter in `vkQueueSubmit`
  - [Synchronized internally](#)
- The `fence` parameter in `vkQueueSubmit`
- The `queue` parameter in `vkQueueWaitIdle`
  - [Synchronized internally](#)
- The `memory` parameter in `vkFreeMemory`

- The `memory` parameter in `vkMapMemory`
- The `memory` parameter in `vkUnmapMemory`
- The `buffer` parameter in `vkBindBufferMemory`
- The `image` parameter in `vkBindImageMemory`
- The `queue` parameter in `vkQueueBindSparse`
- The `fence` parameter in `vkQueueBindSparse`
- The `fence` parameter in `vkDestroyFence`
  - **Consequence of shared pointer usage**
- The `semaphore` parameter in `vkDestroySemaphore`
  - **Consequence of shared pointer usage**
- The `event` parameter in `vkDestroyEvent`
- The `event` parameter in `vkSetEvent`
- The `event` parameter in `vkResetEvent`
- The `queryPool` parameter in `vkDestroyQueryPool`
- The `buffer` parameter in `vkDestroyBuffer`
- The `bufferView` parameter in `vkDestroyBufferView`
- The `image` parameter in `vkDestroyImage`
  - **Consequence of shared pointer usage**
- The `imageView` parameter in `vkDestroyImageView`
- The `shaderModule` parameter in `vkDestroyShaderModule`
- The `pipelineCache` parameter in `vkDestroyPipelineCache`
- The `dstCache` parameter in `vkMergePipelineCaches`
- The `pipeline` parameter in `vkDestroyPipeline`
- The `pipelineLayout` parameter in `vkDestroyPipelineLayout`
- The `sampler` parameter in `vkDestroySampler`
- The `descriptorsetLayout` parameter in `vkDestroyDescriptorSetLayout`
- The `descriptorPool` parameter in `vkDestroyDescriptorPool`
- The `descriptorPool` parameter in `vkResetDescriptorPool`
- The `descriptorPool` member of the `pAllocateInfo` parameter in `vkAllocateDescriptorSets`
- The `descriptorPool` parameter in `vkFreeDescriptorSets`
- The `framebuffer` parameter in `vkDestroyFramebuffer`
- The `renderPass` parameter in `vkDestroyRenderPass`
- The `commandPool` parameter in `vkDestroyCommandPool`
  - **Consequence of shared pointer usage**
- The `commandPool` parameter in `vkResetCommandPool`
  - **Synchronized internally**
- The `commandPool` member of the `pAllocateInfo` parameter in `vkAllocateCommandBuffers`
  - **Synchronized internally**
- The `commandPool` parameter in `vkFreeCommandBuffers`
  - **Synchronized internally**
- The `commandBuffer` parameter in `vkBeginCommandBuffer`
- The `commandBuffer` parameter in `vkEndCommandBuffer`
- The `commandBuffer` parameter in `vkResetCommandBuffer`
- The `commandBuffer` parameter in `vkCmdBindPipeline`
- The `commandBuffer` parameter in `vkCmdSetViewport`
- The `commandBuffer` parameter in `vkCmdSetScissor`
- The `commandBuffer` parameter in `vkCmdSetLineWidth`
- The `commandBuffer` parameter in `vkCmdSetDepthBias`
- The `commandBuffer` parameter in `vkCmdSetBlendConstants`
- The `commandBuffer` parameter in `vkCmdSetDepthBounds`
- The `commandBuffer` parameter in `vkCmdSetStencilCompareMask`
- The `commandBuffer` parameter in `vkCmdSetStencilWriteMask`

- The `commandBuffer` parameter in `vkCmdSetStencilReference`
- The `commandBuffer` parameter in `vkCmdBindDescriptorSets`
- The `commandBuffer` parameter in `vkCmdBindIndexBuffer`
- The `commandBuffer` parameter in `vkCmdBindVertexBuffers`
- The `commandBuffer` parameter in `vkCmdDraw`
- The `commandBuffer` parameter in `vkCmdDrawIndexed`
- The `commandBuffer` parameter in `vkCmdDrawIndirect`
- The `commandBuffer` parameter in `vkCmdDrawIndexedIndirect`
- The `commandBuffer` parameter in `vkCmdDispatch`
- The `commandBuffer` parameter in `vkCmdDispatchIndirect`
- The `commandBuffer` parameter in `vkCmdCopyBuffer`
- The `commandBuffer` parameter in `vkCmdCopyImage`
- The `commandBuffer` parameter in `vkCmdBlitImage`
- The `commandBuffer` parameter in `vkCmdCopyBufferToImage`
- The `commandBuffer` parameter in `vkCmdCopyImageToBuffer`
- The `commandBuffer` parameter in `vkCmdUpdateBuffer`
- The `commandBuffer` parameter in `vkCmdFillBuffer`
- The `commandBuffer` parameter in `vkCmdClearColorImage`
- The `commandBuffer` parameter in `vkCmdClearDepthStencilImage`
- The `commandBuffer` parameter in `vkCmdClearAttachments`
- The `commandBuffer` parameter in `vkCmdResolveImage`
- The `commandBuffer` parameter in `vkCmdSetEvent`
- The `commandBuffer` parameter in `vkCmdResetEvent`
- The `commandBuffer` parameter in `vkCmdWaitEvents`
- The `commandBuffer` parameter in `vkCmdPipelineBarrier`
- The `commandBuffer` parameter in `vkCmdBeginQuery`
- The `commandBuffer` parameter in `vkCmdEndQuery`
- The `commandBuffer` parameter in `vkCmdResetQueryPool`
- The `commandBuffer` parameter in `vkCmdWriteTimestamp`
- The `commandBuffer` parameter in `vkCmdCopyQueryPoolResults`
- The `commandBuffer` parameter in `vkCmdPushConstants`
- The `commandBuffer` parameter in `vkCmdBeginRenderPass`
- The `commandBuffer` parameter in `vkCmdNextSubpass`
- The `commandBuffer` parameter in `vkCmdEndRenderPass`
- The `commandBuffer` parameter in `vkCmdExecuteCommands`
- The `commandBuffer` parameter in `vkCmdSetDeviceMask`
- The `commandBuffer` parameter in `vkCmdDispatchBase`
- The `commandPool` parameter in `vkTrimCommandPool`
- The `yccrConversion` parameter in `vkDestroySamplerYccrConversion`
- The `descriptorUpdateTemplate` parameter in `vkDestroyDescriptorUpdateTemplate`
- The `descriptorSet` parameter in `vkUpdateDescriptorSetWithTemplate`
- The `commandBuffer` parameter in `vkCmdDrawIndirectCount`
- The `commandBuffer` parameter in `vkCmdDrawIndexedIndirectCount`
- The `commandBuffer` parameter in `vkCmdBeginRenderPass2`
- The `commandBuffer` parameter in `vkCmdNextSubpass2`
- The `commandBuffer` parameter in `vkCmdEndRenderPass2`
- The `surface` parameter in `vkDestroySurfaceKHR`
  - [Consequence of shared pointer usage](#)
- The `surface` member of the `pCreateInfo` parameter in `vkCreateSwapchainKHR`
  -
- The `oldSwapchain` member of the `pCreateInfo` parameter in `vkCreateSwapchainKHR`
  - [Internally synchronized](#)
- The `swapchain` parameter in `vkDestroySwapchainKHR`
  - [Consequence of shared pointer usage](#)

- The `swapchain` parameter in `vkAcquireNextImageKHR`
- The `semaphore` parameter in `vkAcquireNextImageKHR`
- The `fence` parameter in `vkAcquireNextImageKHR`
- The `queue` parameter in `vkQueuePresentKHR`
- The `surface` parameter in `vkGetDeviceGroupSurfacePresentModesKHR`
- The `surface` parameter in `vkGetPhysicalDevicePresentRectanglesKHR`
- The `display` parameter in `vkCreateDisplayModeKHR`
- The `mode` parameter in `vkGetDisplayPlaneCapabilitiesKHR`
- The `commandBuffer` parameter in `vkCmdSetDeviceMaskKHR`
- The `commandBuffer` parameter in `vkCmdDispatchBaseKHR`
- The `commandPool` parameter in `vkTrimCommandPoolKHR`
- The `commandBuffer` parameter in `vkCmdPushDescriptorSetKHR`
- The `commandBuffer` parameter in `vkCmdPushDescriptorSetWithTemplateKHR`
- The `descriptorUpdateTemplate` parameter in `vkDestroyDescriptorUpdateTemplateKHR`
- The `descriptorSet` parameter in `vkUpdateDescriptorSetWithTemplateKHR`
- The `commandBuffer` parameter in `vkCmdBeginRenderPass2KHR`
- The `commandBuffer` parameter in `vkCmdNextSubpass2KHR`
- The `commandBuffer` parameter in `vkCmdEndRenderPass2KHR`
- The `swapchain` parameter in `vkGetSwapchainStatusKHR`
- The `ycbcrConversion` parameter in `vkDestroySamplerYcbcrConversionKHR`
- The `commandBuffer` parameter in `vkCmdDrawIndirectCountKHR`
- The `commandBuffer` parameter in `vkCmdDrawIndexedIndirectCountKHR`
- The `callback` parameter in `vkDestroyDebugReportCallbackEXT`
- The `object` member of the `pTagInfo` parameter in `vkDebugMarkerSetObjectTagEXT`
- The `object` member of the `pNameInfo` parameter in `vkDebugMarkerSetObjectNameEXT`
- The `commandBuffer` parameter in `vkCmdBindTransformFeedbackBuffersEXT`
- The `commandBuffer` parameter in `vkCmdBeginTransformFeedbackEXT`
- The `commandBuffer` parameter in `vkCmdEndTransformFeedbackEXT`
- The `commandBuffer` parameter in `vkCmdBeginQueryIndexedEXT`
- The `commandBuffer` parameter in `vkCmdEndQueryIndexedEXT`
- The `commandBuffer` parameter in `vkCmdDrawIndirectByteCountEXT`
- The `commandBuffer` parameter in `vkCmdDrawIndirectCountAMD`
- The `commandBuffer` parameter in `vkCmdDrawIndexedIndirectCountAMD`
- The `commandBuffer` parameter in `vkCmdBeginConditionalRenderingEXT`
- The `commandBuffer` parameter in `vkCmdEndConditionalRenderingEXT`
- The `commandBuffer` parameter in `vkCmdProcessCommandsNVX`
- The `commandBuffer` parameter in `vkCmdReserveSpaceForCommandsNVX`
- The `objectTable` parameter in `vkDestroyObjectTableNVX`
- The `objectTable` parameter in `vkRegisterObjectsNVX`
- The `objectTable` parameter in `vkUnregisterObjectsNVX`
- The `commandBuffer` parameter in `vkCmdSetViewportWScalingNV`
- The `swapchain` parameter in `vkGetRefreshCycleDurationGOOGLE`
- The `swapchain` parameter in `vkGetPastPresentationTimingGOOGLE`
- The `commandBuffer` parameter in `vkCmdSetDiscardRectangleEXT`
- The `objectHandle` member of the `pNameInfo` parameter in `vkSetDebugUtilsObjectNameEXT`
- The `objectHandle` member of the `pTagInfo` parameter in `vkSetDebugUtilsObjectTagEXT`
- The `messenger` parameter in `vkDestroyDebugUtilsMessengerEXT`
- The `commandBuffer` parameter in `vkCmdSetSampleLocationsEXT`
- The `validationCache` parameter in `vkDestroyValidationCacheEXT`
- The `dstCache` parameter in `vkMergeValidationCachesEXT`
- The `commandBuffer` parameter in `vkCmdBindShadingRateImageNV`
- The `commandBuffer` parameter in `vkCmdSetViewportShadingRatePaletteNV`
- The `commandBuffer` parameter in `vkCmdSetCoarseSampleOrderNV`
- The `commandBuffer` parameter in `vkCmdWriteBufferMarkerAMD`
- The `commandBuffer` parameter in `vkCmdDrawMeshTasksNV`

- The `commandBuffer` parameter in `vkCmdDrawMeshTasksIndirectNV`
- The `commandBuffer` parameter in `vkCmdDrawMeshTasksIndirectCountNV`
- The `commandBuffer` parameter in `vkCmdSetExclusiveScissorNV`
- The `commandBuffer` parameter in `vkCmdSetLineStippleEXT`

## Validations

There are two types of validations in Vulkan API: Implicit validations, which talk about technical aspects of the API usage, and explicit validations, which talk about semantical aspects. Vulkayes aims to solve all implicit validations in the core crate. External validations are not always trivial to solve, some of them are statically fulfilled using the type system or the API design, others are left to the user.

External validations resolved statically are enclosed in blue boxes below.

### Instance

Validations for `vkCreateInstance`:

- `pCreateInfo` must be a valid pointer to a valid `VkInstanceCreateInfo` structure
- If `pAllocator` is not `NULL`, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
- `pInstance` must be a valid pointer to a `VkInstance` handle

Validations for `VkInstanceCreateInfo`:

- `sType` must be `VK_STRUCTURE_TYPE_INSTANCE_CREATE_INFO`
- Each `pNext` member of any structure (including this one) in the `pNext` chain must be either `NULL` or a pointer to a valid instance of `VkDebugReportCallbackCreateInfoEXT`, `VkDebugUtilsMessengerCreateInfoEXT`, `VkValidationFeaturesEXT`, or `VkValidationFlagsEXT`
- The `sType` value of each struct in the `pNext` chain must be unique
- `flags` must be `0`
- If `pApplicationInfo` is not `NULL`, `pApplicationInfo` must be a valid pointer to a valid `VkApplicationInfo` structure
- If `enabledLayerCount` is not `0`, `ppEnabledLayerNames` must be a valid pointer to an array of `enabledLayerCount` null-terminated UTF-8 strings
- If `enabledExtensionCount` is not `0`, `ppEnabledExtensionNames` must be a valid pointer to an array of `enabledExtensionCount` null-terminated UTF-8 strings

### Device

Validations for `vkCreateDevice`:

- `physicalDevice` must be a valid `VkPhysicalDevice` handle
- `pCreateInfo` must be a valid pointer to a valid `VkDeviceCreateInfo` structure
- If `pAllocator` is not `NULL`, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
- `pDevice` must be a valid pointer to a `VkDevice` handle

Validations for `VkDeviceCreateInfo`:

- `sType` must be `VK_STRUCTURE_TYPE_DEVICE_CREATE_INFO`
- Each `pNext` member of any structure (including this one) in the `pNext` chain must be either `NULL` or a pointer to a valid instance of `VkDeviceGroupDeviceCreateInfo`, `VkDeviceMemoryOverallocationCreateInfoAMD`, `VkPhysicalDevice16BitStorageFeatures`, `VkPhysicalDevice8BitStorageFeatures`, `VkPhysicalDeviceASTCDecodeFeaturesEXT`, `VkPhysicalDeviceBlendOperationAdvancedFeaturesEXT`, `VkPhysicalDeviceBufferDeviceAddressFeatures`, `VkPhysicalDeviceBufferDeviceAddressFeaturesEXT`, `VkPhysicalDeviceCoherentMemoryFeaturesAMD`, `VkPhysicalDeviceComputeShaderDerivativesFeaturesNV`, `VkPhysicalDeviceConditionalRenderingFeaturesEXT`, `VkPhysicalDeviceCooperativeMatrixFeaturesNV`, `VkPhysicalDeviceCornerSampledImageFeaturesNV`, `VkPhysicalDeviceCoverageReductionModeFeaturesNV`, `VkPhysicalDeviceDedicatedAllocationImageAliasingFeaturesNV`, `VkPhysicalDeviceDepthClipEnableFeaturesEXT`, `VkPhysicalDeviceDescriptorIndexingFeatures`, `VkPhysicalDeviceExclusiveScissorFeaturesNV`, `VkPhysicalDeviceFeatures2`, `VkPhysicalDeviceFragmentDensityMapFeaturesEXT`, `VkPhysicalDeviceFragmentShaderBarycentricFeaturesNV`, `VkPhysicalDeviceFragmentShaderInterlockFeaturesEXT`, `VkPhysicalDeviceHostQueryResetFeatures`, `VkPhysicalDeviceImagelessFramebufferFeatures`, `VkPhysicalDeviceIndexTypeUint8FeaturesEXT`, `VkPhysicalDeviceInlineUniformBlockFeaturesEXT`, `VkPhysicalDeviceLineRasterizationFeaturesEXT`, `VkPhysicalDeviceMemoryPriorityFeaturesEXT`, `VkPhysicalDeviceMeshShaderFeaturesNV`, `VkPhysicalDeviceMultiviewFeatures`, `VkPhysicalDevicePerformanceQueryFeaturesKHR`, `VkPhysicalDevicePipelineExecutablePropertiesFeaturesKHR`, `VkPhysicalDeviceProtectedMemoryFeatures`, `VkPhysicalDeviceRepresentativeFragmentTestFeaturesNV`, `VkPhysicalDeviceSamplerYcbcrConversionFeatures`, `VkPhysicalDeviceScalarBlockLayoutFeatures`, `VkPhysicalDeviceSeparateDepthStencilLayoutsFeatures`, `VkPhysicalDeviceShaderAtomicInt64Features`, `VkPhysicalDeviceShaderClockFeaturesKHR`, `VkPhysicalDeviceShaderDemoteToHelperInvocationFeaturesEXT`, `VkPhysicalDeviceShaderDrawParametersFeatures`, `VkPhysicalDeviceShaderFloat16Int8Features`, `VkPhysicalDeviceShaderImageFootprintFeaturesNV`, `VkPhysicalDeviceShaderIntegerFunctions2FeaturesINTEL`, `VkPhysicalDeviceShaderSMBuiltinsFeaturesNV`, `VkPhysicalDeviceShaderSubgroupExtendedTypesFeatures`, `VkPhysicalDeviceShadingRateImageFeaturesNV`, `VkPhysicalDeviceSubgroupSizeControlFeaturesEXT`, `VkPhysicalDeviceTexelBufferAlignmentFeaturesEXT`, `VkPhysicalDeviceTextureCompressionASTCHDRFeaturesEXT`, `VkPhysicalDeviceTimelineSemaphoreFeatures`, `VkPhysicalDeviceTransformFeedbackFeaturesEXT`, `VkPhysicalDeviceUniformBufferStandardLayoutFeatures`, `VkPhysicalDeviceVariablePointersFeatures`, `VkPhysicalDeviceVertexAttributeDivisorFeaturesEXT`, `VkPhysicalDeviceVulkan11Features`, `VkPhysicalDeviceVulkan12Features`,

- `sType` must be `VkPhysicalDeviceVulkanMemoryModelFeatures`, or `VkPhysicalDeviceYcbcrImageArraysFeaturesEXT`
- The `sType` value of each struct in the `pNext` chain must be unique
- `flags` must be `0`
- `pQueueCreateInfos` must be a valid pointer to an array of `queueCreateInfoCount` valid `VkDeviceQueueCreateInfo` structures
- If `enabledLayerCount` is not `0`, `ppEnabledLayerNames` must be a valid pointer to an array of `enabledLayerCount` null-terminated UTF-8 strings
- If `enabledExtensionCount` is not `0`, `ppEnabledExtensionNames` must be a valid pointer to an array of `enabledExtensionCount` null-terminated UTF-8 strings
- If `pEnabledFeatures` is not `NULL`, `pEnabledFeatures` must be a valid pointer to a valid `VkPhysicalDeviceFeatures` structure
- `queueCreateInfoCount` must be greater than `0`

Validations for `VkDeviceQueueCreateInfo`:

- `sType` must be `VK_STRUCTURE_TYPE_DEVICE_QUEUE_CREATE_INFO`
- `pNext` must be `NULL` or a pointer to a valid instance of `VkDeviceQueueGlobalPriorityCreateInfoEXT`
- The `sType` value of each struct in the `pNext` chain must be unique
- `flags` must be a valid combination of `VkDeviceQueueCreateFlagBits` values
- `pQueuePriorities` must be a valid pointer to an array of `queueCount` `float` values
- `queueCount` must be greater than `0`

Validations for `vkCreateSwapchainKHR`:

- `device` must be a valid `VkDevice` handle
- `pCreateInfo` must be a valid pointer to a valid `VkSwapchainCreateInfoKHR` structure
- If `pAllocator` is not `NULL`, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
- `pSwapchain` must be a valid pointer to a `VkSwapchainKHR` handle

Validations for `VkSwapchainCreateInfoKHR`:

- `sType` must be `VK_STRUCTURE_TYPE_SWAPCHAIN_CREATE_INFO_KHR`
- Each `pNext` member of any structure (including this one) in the `pNext` chain must be either `NULL` or a pointer to a valid instance of `VkDeviceGroupSwapchainCreateInfoKHR`, `VkImageFormatListCreateInfo`, `VkSurfaceFullScreenExclusiveCreateInfoEXT`, `VkSurfaceFullScreenExclusiveWin32CreateInfoEXT`, `VkSwapchainCounterCreateInfoEXT`, or `VkSwapchainDisplayNativeHdrCreateInfoAMD`
- The `sType` value of each struct in the `pNext` chain must be unique
- `flags` must be a valid combination of `VkSwapchainCreateFlagBitsKHR` values
- `surface` must be a valid `VkSurfaceKHR` handle
- `imageFormat` must be a valid `VkFormat` value
- `imageColorSpace` must be a valid `VkColorSpaceKHR` value
- `imageUsage` must be a valid combination of `VkImageUsageFlagBits` values
- `imageUsage` must not be `0`
- `imageSharingMode` must be a valid `VkSharingMode` value
- `preTransform` must be a valid `VkSurfaceTransformFlagBitsKHR` value
- `compositeAlpha` must be a valid `VkCompositeAlphaFlagBitsKHR` value
- `presentMode` must be a valid `VkPresentModeKHR` value
- If `oldSwapchain` is not `VK_NULL_HANDLE`, `oldSwapchain` must be a valid `VkSwapchainKHR` handle
- If `oldSwapchain` is a valid handle, it must have been created, allocated, or retrieved from

`surface`

- Both of `oldSwapchain`, and `surface` that are valid handles of non-ignored parameters must have been created, allocated, or retrieved from the same `VkInstance`

Validations for `vkCreateCommandPool`:

- `device` must be a valid `VkDevice` handle
- `pCreateInfo` must be a valid pointer to a valid `VkCommandPoolCreateInfo` structure
- If `pAllocator` is not `NULL`, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
- `pCommandPool` must be a valid pointer to a `VkCommandPool` handle

Validations for `VkCommandPoolCreateInfo`:

- `sType` must be `VK_STRUCTURE_TYPE_COMMAND_POOL_CREATE_INFO`
- `pNext` must be `NULL`
- `flags` must be a valid combination of `VkCommandPoolCreateFlagBits` values

Validations for `VkCommandBufferAllocateInfo`:

- `device` must be a valid `VkDevice` handle
- `pAllocateInfo` must be a valid pointer to a valid `VkCommandBufferAllocateInfo` structure
- `pCommandBuffers` must be a valid pointer to an array of `pAllocateInfo::commandBufferCount` `VkCommandBuffer` handles
- The value referenced by `pAllocateInfo::commandBufferCount` must be greater than `0`

## Instance

Validations for `vkCreateInstance`:

- All required extensions for each extension in the `VkInstanceCreateInfo::ppEnabledExtensionNames` list must also be present in that list.

## Device

Validations for `vkCreateDevice`:

- All required extensions for each extension in the `VkDeviceCreateInfo::ppEnabledExtensionNames` list must also be present in that list.

Validations for `VkDeviceCreateInfo`:

- The `queueFamilyIndex` member of each element of `pQueueCreateInfos` must be unique within `pQueueCreateInfos`, except that two members can share the same `queueFamilyIndex` if one is a protected-capable queue and one is not a protected-capable queue
- If the `pNext` chain includes a `VkPhysicalDeviceFeatures2` structure, then `pEnabledFeatures` must be `NULL`
  - [Handled by API design](#)
- `ppEnabledExtensionNames` must not contain `VK_AMD_negative_viewport_height`
- `ppEnabledExtensionNames` must not contain both `VK_KHR_buffer_device_address` and `VK_EXT_buffer_device_address`

- If the pNext chain includes a `VkPhysicalDeviceVulkan11Features` structure, then it must not include a `VkPhysicalDevice16BitStorageFeatures`, `VkPhysicalDeviceMultiviewFeatures`, `VkPhysicalDeviceVariablePointersFeatures`, `VkPhysicalDeviceProtectedMemoryFeatures`, `VkPhysicalDeviceSamplerYcbcConversionFeatures`, or `VkPhysicalDeviceShaderDrawParametersFeatures` structure
  - [Handled by API design](#)
- If the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then it must not include a `VkPhysicalDevice8BitStorageFeatures`, `VkPhysicalDeviceShaderAtomicInt64Features`, `VkPhysicalDeviceShaderFloat16Int8Features`, `VkPhysicalDeviceDescriptorIndexingFeatures`, `VkPhysicalDeviceScalarBlockLayoutFeatures`, `VkPhysicalDeviceImagelessFramebufferFeatures`, `VkPhysicalDeviceUniformBufferStandardLayoutFeatures`, `VkPhysicalDeviceShaderSubgroupExtendedTypesFeatures`, `VkPhysicalDeviceSeparateDepthStencilLayoutsFeatures`, `VkPhysicalDeviceHostQueryResetFeatures`, `VkPhysicalDeviceTimelineSemaphoreFeatures`, `VkPhysicalDeviceBufferDeviceAddressFeatures`, or `VkPhysicalDeviceVulkanMemoryModelFeatures` structure
  - [Handled by API design](#)
- If ppEnabledExtensions contains code:“`VK_KHR_draw_indirect_count`” and the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then `VkPhysicalDeviceVulkan12Features::drawIndirectCount` must be `VK_TRUE`
  - [Handled by API design](#)
- If ppEnabledExtensions contains code:“`VK_KHR_sampler_mirror_clamp_to_edge`” and the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then `VkPhysicalDeviceVulkan12Features::samplerMirrorClampToEdge` must be `VK_TRUE`
  - [Handled by API design](#)
- If ppEnabledExtensions contains code:“`VK_EXT_descriptor_indexing`” and the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then `VkPhysicalDeviceVulkan12Features::descriptorIndexing` must be `VK_TRUE`
  - [Handled by API design](#)
- If ppEnabledExtensions contains code:“`VK_EXT_sampler_filter_minmax`” and the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then `VkPhysicalDeviceVulkan12Features::samplerFilterMinmax` must be `VK_TRUE`
  - [Handled by API design](#)
- If ppEnabledExtensions contains code:“`VK_EXT_shader_viewport_index_layer`” and the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then `VkPhysicalDeviceVulkan12Features::shaderOutputViewportIndex` and `VkPhysicalDeviceVulkan12Features::shaderOutputLayer` must both be `VK_TRUE`
  - [Handled by API design](#)

## Queue

Validations for `VkDeviceQueueCreateInfo`:

- `queueFamilyIndex` must be less than `pQueueFamilyPropertyCount` returned by `vkGetPhysicalDeviceQueueFamilyProperties`
- `queueCount` must be less than or equal to the `queueCount` member of the `VkQueueFamilyProperties` structure, as returned by `vkGetPhysicalDeviceQueueFamilyProperties` in the `pQueueFamilyProperties[queueFamilyIndex]`
- Each element of `pQueuePriorities` must be between `0.0` and `1.0` inclusive

- If the protected memory feature is not enabled, the `VK_DEVICE_QUEUE_CREATE_PROTECTED_BIT` bit of `Flags` must not be set.
  - Handled by API design

## Swapchain

Validations for `VkSwapchainCreateInfoKHR`:

- `surface` must be a surface that is supported by the device as determined using `vkGetPhysicalDeviceSurfaceSupportKHR`
- `minImageCount` must be less than or equal to the value returned in the `maxImageCount` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface if the returned `maxImageCount` is not zero
- If `presentMode` is not `VK_PRESENT_MODE_SHARED_DEMAND_REFRESH_KHR` nor `VK_PRESENT_MODE_SHARED_CONTINUOUS_REFRESH_KHR`, then `minImageCount` must be greater than or equal to the value returned in the `minImageCount` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface
- `minImageCount` must be 1 if `presentMode` is either `VK_PRESENT_MODE_SHARED_DEMAND_REFRESH_KHR` or `VK_PRESENT_MODE_SHARED_CONTINUOUS_REFRESH_KHR`
- `imageFormat` and `imageColorSpace` must match the `format` and `colorSpace` members, respectively, of one of the `VkSurfaceFormatKHR` structures returned by `vkGetPhysicalDeviceSurfaceFormatsKHR` for the surface
- `imageExtent` must be between `minImageExtent` and `maxImageExtent`, inclusive, where `minImageExtent` and `maxImageExtent` are members of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface
- `imageExtent` members `width` and `height` must both be non-zero
  - Guaranteed by the type system
- `imageArrayLayers` must be greater than 0 and less than or equal to the `maxImageArrayLayers` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface
  - Lower bound guaranteed by the type system
- If `presentMode` is `VK_PRESENT_MODE_IMMEDIATE_KHR`, `VK_PRESENT_MODE_MAILBOX_KHR`, `VK_PRESENT_MODE_FIFO_KHR` or `VK_PRESENT_MODE_FIFO_RELAXED_KHR`, `imageUsage` must be a subset of the supported usage flags present in the `supportedUsageFlags` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for surface
- If `presentMode` is `VK_PRESENT_MODE_SHARED_DEMAND_REFRESH_KHR` or `VK_PRESENT_MODE_SHARED_CONTINUOUS_REFRESH_KHR`, `imageUsage` must be a subset of the supported usage flags present in the `sharedPresentSupportedUsageFlags` member of the `VkSharedPresentSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilities2KHR` for surface
  - Guaranteed by the type system
- If `imageSharingMode` is `VK_SHARING_MODE_CONCURRENT`, `pQueueFamilyIndices` must be a valid pointer to an array of `queueFamilyIndexCount` `uint32_t` values
  - Guaranteed by the type system
- If `imageSharingMode` is `VK_SHARING_MODE_CONCURRENT`, `queueFamilyIndexCount` must be greater than 1
  - Guaranteed by the type system
- If `imageSharingMode` is `VK_SHARING_MODE_CONCURRENT`, each element of `pQueueFamilyIndices` must be unique and must be less than `pQueueFamilyPropertyCount`

returned by either `vkGetPhysicalDeviceQueueFamilyProperties` or `vkGetPhysicalDeviceQueueFamilyProperties2` for the `physicalDevice` that was used to create device

- `preTransform` must be one of the bits present in the `supportedTransforms` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface
  - `compositeAlpha` must be one of the bits present in the `supportedCompositeAlpha` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface
  - `presentMode` must be one of the `VkPresentModeKHR` values returned by `vkGetPhysicalDeviceSurfacePresentModesKHR` for the surface
- If the logical device was created with `VkDeviceGroupDeviceCreateInfo::physicalDeviceCount` equal to 1, `flags` must not contain `VK_SWAPCHAIN_CREATE_SPLIT_INSTANCE_BIND_REGIONS_BIT_KHR`
    - [Handled by API design](#)
  - If `oldSwapchain` is not `VK_NULL_HANDLE`, `oldSwapchain` must be a non-retired swapchain associated with native window referred to by `surface`
    - [Handled by API design](#)
- The implied image creation parameters of the swapchain must be supported as reported by `vkGetPhysicalDeviceImageFormatProperties`
  - If `flags` contains `VK_SWAPCHAIN_CREATE_MUTABLE_FORMAT_BIT_KHR` then the `pNext` chain must include a `VkImageFormatListCreateInfo` structure with a `viewFormatCount` greater than zero and `pViewFormats` must have an element equal to `imageFormat`
    - [Handled by API design](#)
  - If `flags` contains `VK_SWAPCHAIN_CREATE_PROTECTED_BIT_KHR`, then `VkSurfaceProtectedCapabilitiesKHR::supportsProtected` must be `VK_TRUE` in the `VkSurfaceProtectedCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilities2KHR` for surface
    - [Handled by API design](#)
  - If the `pNext` chain includes a `VkSurfaceFullScreenExclusiveInfoEXT` structure with its `fullScreenExclusive` member set to `VK_FULL_SCREEN_EXCLUSIVE_APPLICATION_CONTROLLED_EXT`, and `surface` was created using `vkCreateWin32SurfaceKHR`, a `VkSurfaceFullScreenExclusiveWin32InfoEXT` structure must be included in the `pNext` chain
    - [Handled by API design](#)

## Command buffer

Validations for `vkCreateCommandPool`:

- `pCreateInfo->queueFamilyIndex` must be the index of a queue family available in the logical device `device`.
    - [Handled by API design](#)

Validations for `VkCommandPoolCreateInfo`:

- If the protected memory feature is not enabled, the `VK_COMMAND_POOL_CREATE_PROTECTED_BIT` bit of `flags` must not be set.
    - [Handled by API design](#)

Validations for `VkCommandBufferAllocateInfo`:

- commandBufferCount must be greater than 0
  - Guaranteed by the type system

## Render pass

Validations for `VkRenderPassCreateInfo2`:

- If any two subpasses operate on attachments with overlapping ranges of the same `VkDeviceMemory` object, and at least one subpass writes to that area of `VkDeviceMemory`, a subpass dependency must be included (either directly or via some intermediate subpasses) between them
- If the attachment member of any element of `pInputAttachments`, `pColorAttachments`, `pResolveAttachments` or `pDepthStencilAttachment`, or the attachment indexed by any element of `pPreserveAttachments` in any given element of `pSubpasses` is bound to a range of a `VkDeviceMemory` object that overlaps with any other attachment in any subpass (including the same subpass), the `VkAttachmentDescription2` structures describing them must include `VK_ATTACHMENT_DESCRIPTION_MAY_ALIAS_BIT` in `flags`
- If the attachment member of any element of `pInputAttachments`, `pColorAttachments`, `pResolveAttachments` or `pDepthStencilAttachment`, or any element of `pPreserveAttachments` in any given element of `pSubpasses` is not `VK_ATTACHMENT_UNUSED`, it must be less than `attachmentCount`
- For any member of `pAttachments` with a `loadOp` equal to `VK_ATTACHMENT_LOAD_OP_CLEAR`, the first use of that attachment must not specify a `layout` equal to `VK_IMAGE_LAYOUT_SHADER_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_STENCIL_READ_ONLY_OPTIMAL`, or `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_STENCIL_ATTACHMENT_OPTIMAL`
- For any member of `pAttachments` with a `stencilLoadOp` equal to `VK_ATTACHMENT_LOAD_OP_CLEAR`, the first use of that attachment must not specify a `layout` equal to `VK_IMAGE_LAYOUT_SHADER_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_STENCIL_READ_ONLY_OPTIMAL`, or `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_STENCIL_READ_ONLY_OPTIMAL`.
- For any element of `pDependencies`, if the `srcSubpass` is not `VK_SUBPASS_EXTERNAL`, all stage flags included in the `srcStageMask` member of that dependency must be a pipeline stage supported by the `pipelineBindPoint` member of the source subpass
- For any element of `pDependencies`, if the `dstSubpass` is not `VK_SUBPASS_EXTERNAL`, all stage flags included in the `dstStageMask` member of that dependency must be a pipeline stage supported by the `pipelineBindPoint` member of the destination subpass
- The set of bits included in any element of `pCorrelatedViewMasks` must not overlap with the set of bits included in any other element of `pCorrelatedViewMasks`
- If the `VkSubpassDescription2::viewMask` member of all elements of `pSubpasses` is 0, `correlatedViewMaskCount` must be 0
- The `VkSubpassDescription2::viewMask` member of all elements of `pSubpasses` must either all be 0, or all not be 0
- If the `VkSubpassDescription2::viewMask` member of all elements of `pSubpasses` is 0, the `dependencyFlags` member of any element of `pDependencies` must not include `VK_DEPENDENCY_VIEW_LOCAL_BIT`
- For any element of `pDependencies` where its `srcSubpass` member equals its `dstSubpass` member, if the `viewMask` member of the corresponding element of `pSubpasses` includes more than one bit, its `dependencyFlags` member must include `VK_DEPENDENCY_VIEW_LOCAL_BIT`
- The `viewMask` member must not have a bit set at an index greater than or equal to `VkPhysicalDeviceLimits::maxFramebufferLayers`
- If the attachment member of any element of the `pInputAttachments` member of any element of `pSubpasses` is not `VK_ATTACHMENT_UNUSED`, the `aspectMask` member of that element of

`pInputAttachments` must only include aspects that are present in images of the format specified by the element of `pAttachments` specified by attachment

- The `srcSubpass` member of each element of `pDependencies` must be less than `subpassCount`
- The `dstSubpass` member of each element of `pDependencies` must be less than `subpassCount`

Validations for `VkAttachmentDescription2`:

- `finalLayout` must not be `VK_IMAGE_LAYOUT_UNDEFINED` or `VK_IMAGE_LAYOUT_PREINITIALIZED`
- If format is a color format, `initialLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_STENCIL_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_STENCIL_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_STENCIL_READ_ONLY_OPTIMAL`, or `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_STENCIL_ATTACHMENT_OPTIMAL`
- If format is a depth/stencil format, `initialLayout` must not be `VK_IMAGE_LAYOUT_COLOR_ATTACHMENT_OPTIMAL`
- If format is a color format, `finalLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_STENCIL_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_STENCIL_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_STENCIL_READ_ONLY_OPTIMAL`, or `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_STENCIL_ATTACHMENT_OPTIMAL`
- If format is a depth/stencil format, `finalLayout` must not be `VK_IMAGE_LAYOUT_COLOR_ATTACHMENT_OPTIMAL`
- If the `separateDepthStencilLayouts` feature is not enabled, `initialLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_STENCIL_ATTACHMENT_OPTIMAL` or `VK_IMAGE_LAYOUT_STENCIL_READ_ONLY_OPTIMAL`
- If the `separateDepthStencilLayouts` feature is not enabled, `finalLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_STENCIL_ATTACHMENT_OPTIMAL` or `VK_IMAGE_LAYOUT_STENCIL_READ_ONLY_OPTIMAL`
- If format is a color format, `initialLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_STENCIL_ATTACHMENT_OPTIMAL` or `VK_IMAGE_LAYOUT_STENCIL_READ_ONLY_OPTIMAL`
- If format is a color format, `finalLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_STENCIL_ATTACHMENT_OPTIMAL` or `VK_IMAGE_LAYOUT_STENCIL_READ_ONLY_OPTIMAL`
- If format is a depth/stencil format which includes both depth and stencil aspects, and `initialLayout` is `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL` or `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`, the `pNext` chain must include a `VkAttachmentDescriptionStencilLayout` structure
- If format is a depth/stencil format which includes both depth and stencil aspects, and `finalLayout` is `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL` or `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`, the `pNext` chain must include a `VkAttachmentDescriptionStencilLayout` structure
- If format is a depth/stencil format which includes only the depth aspect, `initialLayout` must not be `VK_IMAGE_LAYOUT_STENCIL_ATTACHMENT_OPTIMAL` or `VK_IMAGE_LAYOUT_STENCIL_READ_ONLY_OPTIMAL`
- If format is a depth/stencil format which includes only the depth aspect, `finalLayout` must not

- be `VK_IMAGE_LAYOUT_STENCIL_ATTACHMENT_OPTIMAL` or `VK_IMAGE_LAYOUT_STENCIL_READ_ONLY_OPTIMAL`
- If `format` is a depth/stencil format which includes only the stencil aspect, `initialLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL` or `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`
- If `format` is a depth/stencil format which includes only the stencil aspect, `finalLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL` or `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`

Validations for `VkSubpassDescription2`:

- `pipelineBindPoint` must be `VK_PIPELINE_BIND_POINT_GRAPHICS`
- `colorAttachmentCount` must be less than or equal to `VkPhysicalDeviceLimits::maxColorAttachments`
- If the first use of an attachment in this render pass is as an input attachment, and the attachment is not also used as a color or depth/stencil attachment in the same subpass, then `loadOp` must not be `VK_ATTACHMENT_LOAD_OP_CLEAR`
- If `pResolveAttachments` is not `NULL`, for each resolve attachment that does not have the value `VK_ATTACHMENT_UNUSED`, the corresponding color attachment must not have the value `VK_ATTACHMENT_UNUSED`
- If `pResolveAttachments` is not `NULL`, for each resolve attachment that is not `VK_ATTACHMENT_UNUSED`, the corresponding color attachment must not have a sample count of `VK_SAMPLE_COUNT_1_BIT`
- If `pResolveAttachments` is not `NULL`, each resolve attachment that is not `VK_ATTACHMENT_UNUSED` must have a sample count of `VK_SAMPLE_COUNT_1_BIT`
- Any given element of `pResolveAttachments` must have the same `VkFormat` as its corresponding color attachment
- All attachments in `pColorAttachments` that are not `VK_ATTACHMENT_UNUSED` must have the same sample count
- If the `VK_AMD_mixed_attachment_samples` extension is enabled, all attachments in `pColorAttachments` that are not `VK_ATTACHMENT_UNUSED` must have a sample count that is smaller than or equal to the sample count of `pDepthStencilAttachment` if it is not `VK_ATTACHMENT_UNUSED`
- If neither the `VK_AMD_mixed_attachment_samples` nor the `VK_NV_framebuffer_mixed_samples` extensions are enabled, and if `pDepthStencilAttachment` is not `VK_ATTACHMENT_UNUSED` and any attachments in `pColorAttachments` are not `VK_ATTACHMENT_UNUSED`, they must have the same sample count
- The `attachment` member of any element of `pPreserveAttachments` must not be `VK_ATTACHMENT_UNUSED`
- Any given element of `pPreserveAttachments` must not also be an element of any other member of the subpass description
- If any attachment is used by more than one `VkAttachmentReference` member, then each use must use the same `layout`
- If `flags` includes `VK_SUBPASS_DESCRIPTION_PER_VIEW_POSITION_X_ONLY_BIT_NVX`, it must also include `VK_SUBPASS_DESCRIPTION_PER_VIEW_ATTRIBUTES_BIT_NVX`.
- If the `attachment` member of any element of `pInputAttachments` is not `VK_ATTACHMENT_UNUSED`, then the `aspectMask` member must be a valid combination of `VkImageAspectFlagBits`
- If the `attachment` member of any element of `pInputAttachments` is not `VK_ATTACHMENT_UNUSED`, then the `aspectMask` member must not be `0`
- If the `attachment` member of any element of `pInputAttachments` is not `VK_ATTACHMENT_UNUSED`, then the `aspectMask` member must not include `VK_IMAGE_ASPECT_METADATA_BIT`

Validations for `VkAttachmentReference2`:

- If attachment is not VK\_ATTACHMENT\_UNUSED, layout must not be VK\_IMAGE\_LAYOUT\_UNDEFINED, VK\_IMAGE\_LAYOUT\_PREINITIALIZED, or VK\_IMAGE\_LAYOUT\_PRESENT\_SRC\_KHR
- If attachment is not VK\_ATTACHMENT\_UNUSED, and aspectMask does not include VK\_IMAGE\_ASPECT\_STENCIL\_BIT or VK\_IMAGE\_ASPECT\_DEPTH\_BIT, layout must not be VK\_IMAGE\_LAYOUT\_DEPTH\_STENCIL\_ATTACHMENT\_OPTIMAL, VK\_IMAGE\_LAYOUT\_DEPTH\_STENCIL\_READ\_ONLY\_OPTIMAL, VK\_IMAGE\_LAYOUT\_DEPTH\_ATTACHMENT\_STENCIL\_READ\_ONLY\_OPTIMAL, or VK\_IMAGE\_LAYOUT\_DEPTH\_READ\_ONLY\_STENCIL\_ATTACHMENT\_OPTIMAL
- If attachment is not VK\_ATTACHMENT\_UNUSED, and aspectMask does not include VK\_IMAGE\_ASPECT\_COLOR\_BIT, layout must not be VK\_IMAGE\_LAYOUT\_COLOR\_ATTACHMENT\_OPTIMAL
- If the separateDepthStencilLayouts feature is not enabled, and attachment is not VK\_ATTACHMENT\_UNUSED, layout must not be VK\_IMAGE\_LAYOUT\_DEPTH\_ATTACHMENT\_OPTIMAL, VK\_IMAGE\_LAYOUT\_DEPTH\_READ\_ONLY\_OPTIMAL, VK\_IMAGE\_LAYOUT\_STENCIL\_ATTACHMENT\_OPTIMAL, or VK\_IMAGE\_LAYOUT\_STENCIL\_READ\_ONLY\_OPTIMAL,
- If attachment is not VK\_ATTACHMENT\_UNUSED, and aspectMask includes VK\_IMAGE\_ASPECT\_COLOR\_BIT, layout must not be VK\_IMAGE\_LAYOUT\_DEPTH\_ATTACHMENT\_OPTIMAL, VK\_IMAGE\_LAYOUT\_DEPTH\_READ\_ONLY\_OPTIMAL, VK\_IMAGE\_LAYOUT\_STENCIL\_ATTACHMENT\_OPTIMAL, or VK\_IMAGE\_LAYOUT\_STENCIL\_READ\_ONLY\_OPTIMAL,
- If attachment is not VK\_ATTACHMENT\_UNUSED, and aspectMask includes both VK\_IMAGE\_ASPECT\_DEPTH\_BIT and VK\_IMAGE\_ASPECT\_STENCIL\_BIT, and layout is VK\_IMAGE\_LAYOUT\_DEPTH\_ATTACHMENT\_OPTIMAL or VK\_IMAGE\_LAYOUT\_DEPTH\_READ\_ONLY\_OPTIMAL, the pNext chain must include a VkAttachmentReferenceStencilLayout structure
- If attachment is not VK\_ATTACHMENT\_UNUSED, and aspectMask includes only VK\_IMAGE\_ASPECT\_DEPTH\_BIT then layout must not be VK\_IMAGE\_LAYOUT\_STENCIL\_ATTACHMENT\_OPTIMAL, or VK\_IMAGE\_LAYOUT\_STENCIL\_READ\_ONLY\_OPTIMAL
- If attachment is not VK\_ATTACHMENT\_UNUSED, and aspectMask includes only VK\_IMAGE\_ASPECT\_STENCIL\_BIT then layout must not be VK\_IMAGE\_LAYOUT\_DEPTH\_ATTACHMENT\_OPTIMAL, or VK\_IMAGE\_LAYOUT\_DEPTH\_READ\_ONLY\_OPTIMAL

#### Validations for VkSubpassDependency2:

- If the geometry shaders feature is not enabled, srcStageMask must not contain VK\_PIPELINE\_STAGE\_GEOMETRY\_SHADER\_BIT
- If the geometry shaders feature is not enabled, dstStageMask must not contain VK\_PIPELINE\_STAGE\_GEOMETRY\_SHADER\_BIT
- If the tessellation shaders feature is not enabled, srcStageMask must not contain VK\_PIPELINE\_STAGE\_TESSELLATION\_CONTROL\_SHADER\_BIT or VK\_PIPELINE\_STAGE\_TESSELLATION\_EVALUATION\_SHADER\_BIT
- If the tessellation shaders feature is not enabled, dstStageMask must not contain VK\_PIPELINE\_STAGE\_TESSELLATION\_CONTROL\_SHADER\_BIT or VK\_PIPELINE\_STAGE\_TESSELLATION\_EVALUATION\_SHADER\_BIT
- srcSubpass must be less than or equal to dstSubpass, unless one of them is VK\_SUBPASS\_EXTERNAL, to avoid cyclic dependencies and ensure a valid execution order
- srcSubpass and dstSubpass must not both be equal to VK\_SUBPASS\_EXTERNAL
- If srcSubpass is equal to dstSubpass and not all of the stages in srcStageMask and dstStageMask are framebuffer-space stages, the logically latest pipeline stage in srcStageMask

- must be logically earlier than or equal to the logically earliest pipeline stage in `dstStageMask`
- Any access flag included in `srcAccessMask` must be supported by one of the pipeline stages in `srcStageMask`, as specified in the table of supported access types
- Any access flag included in `dstAccessMask` must be supported by one of the pipeline stages in `dstStageMask`, as specified in the table of supported access types
- If `dependencyFlags` includes `VK_DEPENDENCY_VIEW_LOCAL_BIT`, `srcSubpass` must not be equal to `VK_SUBPASS_EXTERNAL`
- If `dependencyFlags` includes `VK_DEPENDENCY_VIEW_LOCAL_BIT`, `dstSubpass` must not be equal to `VK_SUBPASS_EXTERNAL`
- If `srcSubpass` equals `dstSubpass`, and `srcStageMask` and `dstStageMask` both include a framebuffer-space stage, then `dependencyFlags` must include `VK_DEPENDENCY_BY_REGION_BIT`
- If `viewOffset` is not equal to `0`, `srcSubpass` must not be equal to `dstSubpass`
- If `dependencyFlags` does not include `VK_DEPENDENCY_VIEW_LOCAL_BIT`, `viewOffset` must be `0`
- If `viewOffset` is not `0`, `srcSubpass` must not be equal to `dstSubpass`.
- If the mesh shaders feature is not enabled, `srcStageMask` must not contain `VK_PIPELINE_STAGE_MESH_SHADER_BIT_NV`
- If the task shaders feature is not enabled, `srcStageMask` must not contain `VK_PIPELINE_STAGE_TASK_SHADER_BIT_NV`
- If the mesh shaders feature is not enabled, `dstStageMask` must not contain `VK_PIPELINE_STAGE_MESH_SHADER_BIT_NV`
- If the task shaders feature is not enabled, `dstStageMask` must not contain `VK_PIPELINE_STAGE_TASK_SHADER_BIT_NV`

## Framebuffer

Validations for `vkCreateFramebuffer`:

- If `pCreateInfo->flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, and `attachmentCount` is not `0`, each element of `pCreateInfo->pAttachments` must have been created on device

Validations for `VkFramebufferCreateInfo`:

- `attachmentCount` must be equal to the attachment count specified in `renderPass`
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, and `attachmentCount` is not `0`, `pAttachments` must be a valid pointer to an array of `attachmentCount` valid `VkImageView` handles
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` that is used as a color attachment or resolve attachment by `renderPass` must have been created with a `usage` value including `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` that is used as a depth/stencil attachment by `renderPass` must have been created with a `usage` value including `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` that is used as a depth/stencil resolve attachment by `renderPass` must have been created with a `usage` value including `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` that is used as an input attachment by `renderPass` must have been created with a `usage` value including `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`
- Each element of `pAttachments` that is used as a fragment density map attachment by `renderPass` must not have been created with a `flags` value including `VK_IMAGE_CREATE_SUBSAMPLED_BIT_EXT`.
- If `renderPass` has a fragment density map attachment and non-subsample image feature is not

enabled, each element of `pAttachments` must have been created with a `flags` value including `VK_IMAGE_CREATE_SUBSAMPLED_BIT_EXT` unless that element is the fragment density map attachment.

- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` must have been created with a `VkFormat` value that matches the `VkFormat` specified by the corresponding `VkAttachmentDescription` in `renderPass`
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` must have been created with a `samples` value that matches the `samples` value specified by the corresponding `VkAttachmentDescription` in `renderPass`
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` must have dimensions at least as large as the corresponding framebuffer dimension except for any element that is referenced by `fragmentDensityMapAttachment`
- If `renderPass` was specified with non-zero view masks, each element of `pAttachments` that is not referenced by `fragmentDensityMapAttachment` must have a `layerCount` greater than the index of the most significant bit set in any of those view masks
- If `renderPass` was specified with non-zero view masks, each element of `pAttachments` that is referenced by `fragmentDensityMapAttachment` must have a `layerCount` equal to 1 or greater than the index of the most significant bit set in any of those view masks
- If `renderPass` was not specified with non-zero view masks, each element of `pAttachments` that is referenced by `fragmentDensityMapAttachment` must have a `layerCount` equal to 1
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, an element of `pAttachments` that is referenced by `fragmentDensityMapAttachment` must have a width at least as large as  $\lceil \frac{\text{width}}{\maxFragmentDensityTexelSize_{\text{width}}} \rceil$
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, an element of `pAttachments` that is referenced by `fragmentDensityMapAttachment` must have a height at least as large as  $\lceil \frac{\text{height}}{\maxFragmentDensityTexelSize_{\text{height}}} \rceil$
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` must only specify a single mip level
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` must have been created with the identity swizzle
- `width` must be greater than 0.
- `width` must be less than or equal to `VkPhysicalDeviceLimits::maxFramebufferWidth`
- `height` must be greater than 0.
- `height` must be less than or equal to `VkPhysicalDeviceLimits::maxFramebufferHeight`
- `layers` must be greater than 0.
- `layers` must be less than or equal to `VkPhysicalDeviceLimits::maxFramebufferLayers`
- If `renderPass` was specified with non-zero view masks, `layers` must be 1
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` that is a 2D or 2D array image view taken from a 3D image must not be a depth/stencil format
- If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, and `attachmentCount` is not 0, `pAttachments` must be a valid pointer to an array of `attachmentCount` valid `VkImageView` handles
- If the imageless framebuffer feature is not enabled, `flags` must not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`
- If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `pNext` chain must include a `VkFramebufferAttachmentsCreateInfo` structure
- If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `attachmentImageInfoCount` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain must be equal to either zero or `attachmentCount`
- If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `width` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain must be greater than or equal to `width`, except for any element that is referenced by

- VkRenderPassFragmentDensityMapCreateInfoEXT::fragmentDensityMapAttachment in renderPass
- If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `height` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain must be greater than or equal to `height`, except for any element that is referenced by `VkRenderPassFragmentDensityMapCreateInfoEXT::fragmentDensityMapAttachment` in `renderPass`
  - If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `width` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain that is referenced by `VkRenderPassFragmentDensityMapCreateInfoEXT::fragmentDensityMapAttachment` in `renderPass` must be greater than or equal to  $\lceil \frac{width}{maxFragmentDensityTexelSize_{width}} \rceil$
  - If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `height` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain that is referenced by `VkRenderPassFragmentDensityMapCreateInfoEXT::fragmentDensityMapAttachment` in `renderPass` must be greater than or equal to  $\lceil \frac{height}{maxFragmentDensityTexelSize_{height}} \rceil$
  - If multiview is enabled for `renderPass`, and `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `layerCount` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain must be greater than the maximum bit index set in the view mask in the subpasses in which it is used in `renderPass`
  - If multiview is not enabled for `renderPass`, and `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `layerCount` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain must be greater than or equal to `layers`
  - If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `usage` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain that refers to an attachment used as a color attachment or resolve attachment by `renderPass` must include `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`
  - If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `usage` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain that refers to an attachment used as a depth/stencil attachment by `renderPass` must include `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`
  - If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `usage` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain that refers to an attachment used as a depth/stencil resolve attachment by `renderPass` must include `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`
  - If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `usage` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain that refers to an attachment used as an input attachment by `renderPass` must include `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`
  - If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, at least one element of the `pViewFormats` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain must be equal to the corresponding value of `VkAttachmentDescription::format` used to create `renderPass`

## Compute pipeline

Validations for `vkCreateComputePipelines`:

- If the `flags` member of any element of `pCreateInfos` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, and the `basePipelineIndex` member of that same element is not `-1`, `basePipelineIndex` must be less than the index into `pCreateInfos` that corresponds to that element
- If the `flags` member of any element of `pCreateInfos` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, the base pipeline must have been created with the `VK_PIPELINE_CREATE_ALLOW_DERIVATIVES_BIT` flag set

Validations for `VkComputePipelineCreateInfo`:

- If `flags` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, and `basePipelineIndex` is `-1`, `basePipelineHandle` must be a valid handle to a compute `VkPipeline`
- If `flags` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, and `basePipelineHandle` is `VK_NULL_HANDLE`, `basePipelineIndex` must be a valid index into the calling command's `pCreateInfos` parameter
- If `flags` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, and `basePipelineIndex` is not `-1`, `basePipelineHandle` must be `VK_NULL_HANDLE`
- If `flags` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, and `basePipelineHandle` is not `VK_NULL_HANDLE`, `basePipelineIndex` must be `-1`
- The `stage` member of `stage` must be `VK_SHADER_STAGE_COMPUTE_BIT`
- The shader code for the entry point identified by `stage` and the rest of the state identified by this structure must adhere to the pipeline linking rules described in the Shader Interfaces chapter
- `layout` must be consistent with the layout of the compute shader specified in `stage`
- The number of resources in `layout` accessible to the compute shader stage must be less than or equal to `VkPhysicalDeviceLimits::maxPerStageResources`

## Graphics pipeline

Validations for `VkPipelineShaderStageCreateInfo`:

- If the geometry shaders feature is not enabled, `stage` must not be `VK_SHADER_STAGE_GEOMETRY_BIT`
- If the tessellation shaders feature is not enabled, `stage` must not be `VK_SHADER_STAGE_TESSELLATION_CONTROL_BIT` or `VK_SHADER_STAGE_TESSELLATION_EVALUATION_BIT`
- If the mesh shader feature is not enabled, `stage` must not be `VK_SHADER_STAGE_MESH_BIT_NV`
- If the task shader feature is not enabled, `stage` must not be `VK_SHADER_STAGE_TASK_BIT_NV`
- `stage` must not be `VK_SHADER_STAGE_ALL_GRAPHICS`, or `VK_SHADER_STAGE_ALL`
- `pName` must be the name of an `OpEntryPoint` in `module` with an execution model that matches `stage`
- If the identified entry point includes any variable in its interface that is declared with the `ClipDistance BuiltIn` decoration, that variable must not have an array size greater than `VkPhysicalDeviceLimits::maxClipDistances`
- If the identified entry point includes any variable in its interface that is declared with the `CullDistance BuiltIn` decoration, that variable must not have an array size greater than `VkPhysicalDeviceLimits::maxCullDistances`
- If the identified entry point includes any variables in its interface that are declared with the `ClipDistance` or `CullDistance BuiltIn` decoration, those variables must not have array sizes which sum to more than `VkPhysicalDeviceLimits::maxCombinedClipAndCullDistances`
- If the identified entry point includes any variable in its interface that is declared with the `SampleMask BuiltIn` decoration, that variable must not have an array size greater than `VkPhysicalDeviceLimits::maxSampleMaskWords`
- If `stage` is `VK_SHADER_STAGE_VERTEX_BIT`, the identified entry point must not include any input variable in its interface that is decorated with `CullDistance`

- If stage is `VK_SHADER_STAGE_TESSELLATION_CONTROL_BIT` or `VK_SHADER_STAGE_TESSELLATION_EVALUATION_BIT`, and the identified entry point has an `OpExecutionMode` instruction that specifies a patch size with `OutputVertices`, the patch size must be greater than `0` and less than or equal to `VkPhysicalDeviceLimits::maxTessellationPatchSize`
- If stage is `VK_SHADER_STAGE_GEOMETRY_BIT`, the identified entry point must have an `OpExecutionMode` instruction that specifies a maximum output vertex count that is greater than `0` and less than or equal to `VkPhysicalDeviceLimits::maxGeometryOutputVertices`
- If stage is `VK_SHADER_STAGE_GEOMETRY_BIT`, the identified entry point must have an `OpExecutionMode` instruction that specifies an invocation count that is greater than `0` and less than or equal to `VkPhysicalDeviceLimits::maxGeometryShaderInvocations`
- If stage is a vertex processing stage, and the identified entry point writes to `Layer` for any primitive, it must write the same value to `Layer` for all vertices of a given primitive
- If stage is a vertex processing stage, and the identified entry point writes to `ViewportIndex` for any primitive, it must write the same value to `ViewportIndex` for all vertices of a given primitive
- If stage is `VK_SHADER_STAGE_FRAGMENT_BIT`, the identified entry point must not include any output variables in its interface decorated with `CullDistance`
- If stage is `VK_SHADER_STAGE_FRAGMENT_BIT`, and the identified entry point writes to `FragDepth` in any execution path, it must write to `FragDepth` in all execution paths
- If stage is `VK_SHADER_STAGE_FRAGMENT_BIT`, and the identified entry point writes to `FragStencilRefEXT` in any execution path, it must write to `FragStencilRefEXT` in all execution paths
- If stage is `VK_SHADER_STAGE_MESH_BIT_NV`, the identified entry point must have an `OpExecutionMode` instruction that specifies a maximum output vertex count, `OutputVertices`, that is greater than `0` and less than or equal to `VkPhysicalDeviceMeshShaderPropertiesNV::maxMeshOutputVertices`.
- If stage is `VK_SHADER_STAGE_MESH_BIT_NV`, the identified entry point must have an `OpExecutionMode` instruction that specifies a maximum output primitive count, `OutputPrimitivesNV`, that is greater than `0` and less than or equal to `VkPhysicalDeviceMeshShaderPropertiesNV::maxMeshOutputPrimitives`.
- If `flags` has the `VK_PIPELINE_SHADER_STAGE_CREATE_ALLOW_VARYING_SUBGROUP_SIZE_BIT_EXT` flag set, the `subgroupSizeControl` feature must be enabled.
- If `flags` has the `VK_PIPELINE_SHADER_STAGE_CREATE_REQUIRE_FULL_SUBGROUPS_BIT_EXT` flag set, the `computeFullSubgroups` feature must be enabled.
- If a `VkPipelineShaderStageRequiredSubgroupSizeCreateInfoEXT` structure is included in the `pNext` chain, `flags` must not have the `VK_PIPELINE_SHADER_STAGE_CREATE_ALLOW_VARYING_SUBGROUP_SIZE_BIT_EXT` flag set.
- If a `VkPipelineShaderStageRequiredSubgroupSizeCreateInfoEXT` structure is included in the `pNext` chain, the `subgroupSizeControl` feature must be enabled, and `stage` must be a valid bit specified in `requiredSubgroupSizeStages`.
- If a `VkPipelineShaderStageRequiredSubgroupSizeCreateInfoEXT` structure is included in the `pNext` chain and `stage` is `VK_SHADER_STAGE_COMPUTE_BIT`, the local workgroup size of the shader must be less than or equal to the product of `VkPipelineShaderStageRequiredSubgroupSizeCreateInfoEXT::requiredSubgroupSize` and `maxComputeWorkgroupSubgroups`.
- If a `VkPipelineShaderStageRequiredSubgroupSizeCreateInfoEXT` structure is included in the `pNext` chain, and `flags` has the `VK_PIPELINE_SHADER_STAGE_CREATE_REQUIRE_FULL_SUBGROUPS_BIT_EXT` flag set, the local workgroup size in the X dimension of the pipeline must be a multiple of `VkPipelineShaderStageRequiredSubgroupSizeCreateInfoEXT::requiredSubgroupSize`.
- If `flags` has both the `VK_PIPELINE_SHADER_STAGE_CREATE_REQUIRE_FULL_SUBGROUPS_BIT_EXT` and `VK_PIPELINE_SHADER_STAGE_CREATE_ALLOW_VARYING_SUBGROUP_SIZE_BIT_EXT` flags set, the local workgroup size in the X dimension of the pipeline must be a multiple of

`maxSubgroupSize`.

- If `flags` has the `VK_PIPELINE_SHADER_STAGE_CREATE_REQUIRE_FULL_SUBGROUPS_BIT_EXT` flag set and `flags` does not have the `VK_PIPELINE_SHADER_STAGE_CREATE_ALLOW_VARYING_SUBGROUP_SIZE_BIT_EXT` flag set and no `VkPipelineShaderStageRequiredSubgroupSizeCreateInfoEXT` structure is included in the `pNext` chain, the local workgroup size in the X dimension of the pipeline must be a multiple of `subgroupSize`.

Validations for `vkCreateGraphicsPipelines`:

- If the `flags` member of any element of `pCreateInfos` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, and the `basePipelineIndex` member of that same element is not -1, `basePipelineIndex` must be less than the index into `pCreateInfos` that corresponds to that element
- If the `flags` member of any element of `pCreateInfos` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, the base pipeline must have been created with the `VK_PIPELINE_CREATE_ALLOW_DERIVATIVES_BIT` flag set

Validations for `VkGraphicsPipelineCreateInfo`:

- If `flags` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, and `basePipelineIndex` is -1, `basePipelineHandle` must be a valid handle to a graphics `VkPipeline`
- If `flags` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, and `basePipelineHandle` is `VK_NULL_HANDLE`, `basePipelineIndex` must be a valid index into the calling command's `pCreateInfos` parameter
- If `flags` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, and `basePipelineIndex` is not -1, `basePipelineHandle` must be `VK_NULL_HANDLE`
- If `flags` contains the `VK_PIPELINE_CREATE_DERIVATIVE_BIT` flag, and `basePipelineHandle` is not `VK_NULL_HANDLE`, `basePipelineIndex` must be -1
- The `stage` member of each element of `pStages` must be unique
- The geometric shader stages provided in `pStages` must be either from the mesh shading pipeline (`stage` is `VK_SHADER_STAGE_TASK_BIT_NV` or `VK_SHADER_STAGE_MESH_BIT_NV`) or from the primitive shading pipeline (`stage` is `VK_SHADER_STAGE_VERTEX_BIT`, `VK_SHADER_STAGE_TESSELLATION_CONTROL_BIT`, `VK_SHADER_STAGE_TESSELLATION_EVALUATION_BIT`, or `VK_SHADER_STAGE_GEOMETRY_BIT`).
- The `stage` member of one element of `pStages` must be either `VK_SHADER_STAGE_VERTEX_BIT` or `VK_SHADER_STAGE_MESH_BIT_NV`.
- The `stage` member of each element of `pStages` must not be `VK_SHADER_STAGE_COMPUTE_BIT`
- If `pStages` includes a tessellation control shader stage, it must include a tessellation evaluation shader stage
- If `pStages` includes a tessellation evaluation shader stage, it must include a tessellation control shader stage
- If `pStages` includes a tessellation control shader stage and a tessellation evaluation shader stage, `pTessellationState` must be a valid pointer to a valid `VkPipelineTessellationStateCreateInfo` structure
- If `pStages` includes tessellation shader stages, the shader code of at least one stage must contain an `OpExecutionMode` instruction that specifies the type of subdivision in the pipeline
- If `pStages` includes tessellation shader stages, and the shader code of both stages contain an `OpExecutionMode` instruction that specifies the type of subdivision in the pipeline, they must both specify the same subdivision mode
- If `pStages` includes tessellation shader stages, the shader code of at least one stage must contain an `OpExecutionMode` instruction that specifies the output patch size in the pipeline
- If `pStages` includes tessellation shader stages, and the shader code of both contain an `OpExecutionMode` instruction that specifies the out patch size in the pipeline, they must both

- specify the same patch size
- If `pStages` includes tessellation shader stages, the `topology` member of `pInputAssembly` must be `VK_PRIMITIVE_TOPOLOGY_PATCH_LIST`
  - If the `topology` member of `pInputAssembly` is `VK_PRIMITIVE_TOPOLOGY_PATCH_LIST`, `pStages` must include tessellation shader stages
  - If `pStages` includes a geometry shader stage, and does not include any tessellation shader stages, its shader code must contain an `OpExecutionMode` instruction that specifies an input primitive type that is `compatible` with the primitive topology specified in `pInputAssembly`
  - If `pStages` includes a geometry shader stage, and also includes tessellation shader stages, its shader code must contain an `OpExecutionMode` instruction that specifies an input primitive type that is `compatible` with the primitive topology that is output by the tessellation stages
  - If `pStages` includes a fragment shader stage and a geometry shader stage, and the fragment shader code reads from an input variable that is decorated with `PrimitiveID`, then the geometry shader code must write to a matching output variable, decorated with `PrimitiveID`, in all execution paths
  - If `pStages` includes a fragment shader stage, its shader code must not read from any input attachment that is defined as `VK_ATTACHMENT_UNUSED` in subpass
  - The shader code for the entry points identified by `pStages`, and the rest of the state identified by this structure must adhere to the pipeline linking rules described in the Shader Interfaces chapter
  - If rasterization is not disabled and subpass uses a depth/stencil attachment in `renderPass` that has a layout of `VK_IMAGE_LAYOUT_DEPTH_STENCIL_READ_ONLY_OPTIMAL` or `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_STENCIL_ATTACHMENT_OPTIMAL` in the `VkAttachmentReference` defined by subpass, the `depthWriteEnable` member of `pDepthStencilState` must be `VK_FALSE`
  - If rasterization is not disabled and subpass uses a depth/stencil attachment in `renderPass` that has a layout of `VK_IMAGE_LAYOUT_DEPTH_STENCIL_READ_ONLY_OPTIMAL` or `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_STENCIL_READ_ONLY_OPTIMAL` in the `VkAttachmentReference` defined by subpass, the `failOp`, `passOp` and `depthFailOp` members of each of the front and back members of `pDepthStencilState` must be `VK_STENCIL_OP_KEEP`
  - If rasterization is not disabled and the subpass uses color attachments, then for each color attachment in the subpass the `blendEnable` member of the corresponding element of the `pAttachment` member of `pColorBlendState` must be `VK_FALSE` if the attached image's format features does not contain `VK_FORMAT_FEATURE_COLOR_ATTACHMENT_BLEND_BIT`.
  - If rasterization is not disabled and the subpass uses color attachments, the `attachmentCount` member of `pColorBlendState` must be equal to the `colorAttachmentCount` used to create subpass
  - If no element of the `pDynamicStates` member of `pDynamicState` is `VK_DYNAMIC_STATE_VIEWPORT`, the `pViewports` member of `pViewportState` must be a valid pointer to an array of `pViewportState->viewportCount` valid `VkViewport` structures
  - If no element of the `pDynamicStates` member of `pDynamicState` is `VK_DYNAMIC_STATE_SCISSOR`, the `pScissors` member of `pViewportState` must be a valid pointer to an array of `pViewportState->scissorCount` `VkRect2D` structures
  - If the wide lines feature is not enabled, and no element of the `pDynamicStates` member of `pDynamicState` is `VK_DYNAMIC_STATE_LINE_WIDTH`, the `lineWidth` member of `pRasterizationState` must be `1.0`
  - If the `rasterizerDiscardEnable` member of `pRasterizationState` is `VK_FALSE`, `pViewportState` must be a valid pointer to a valid `VkPipelineViewportStateCreateInfo` structure
  - If the `rasterizerDiscardEnable` member of `pRasterizationState` is `VK_FALSE`, `pMultisampleState` must be a valid pointer to a valid `VkPipelineMultisampleStateCreateInfo` structure
  - If the `rasterizerDiscardEnable` member of `pRasterizationState` is `VK_FALSE`, and subpass uses a depth/stencil attachment, `pDepthStencilState` must be a valid pointer to a valid `VkPipelineDepthStencilStateCreateInfo` structure

- If the `rasterizerDiscardEnable` member of `pRasterizationState` is `VK_FALSE`, and subpass uses color attachments, `pColorBlendState` must be a valid pointer to a valid `VkPipelineColorBlendStateCreateInfo` structure
- If the depth bias clamping feature is not enabled, no element of the `pDynamicStates` member of `pDynamicState` is `VK_DYNAMIC_STATE_DEPTH_BIAS`, and the `depthBiasEnable` member of `pRasterizationState` is `VK_TRUE`, the `depthBiasClamp` member of `pRasterizationState` must be `0.0`
- If the `VK_EXT_depth_range_unrestricted` extension is not enabled and no element of the `pDynamicStates` member of `pDynamicState` is `VK_DYNAMIC_STATE_DEPTH_BOUNDS`, and the `depthBoundsTestEnable` member of `pDepthStencilState` is `VK_TRUE`, the `minDepthBounds` and `maxDepthBounds` members of `pDepthStencilState` must be between `0.0` and `1.0`, inclusive
- If no element of the `pDynamicStates` member of `pDynamicState` is `VK_DYNAMIC_STATE_SAMPLE_LOCATIONS_EXT`, and the `sampleLocationsEnable` member of a `VkPipelineSampleLocationsStateCreateInfoEXT` structure included in the `pNext` chain of `pMultisampleState` is `VK_TRUE`, `sampleLocationsInfo.sampleLocationGridSize.width` must evenly divide `VkMultisamplePropertiesEXT::sampleLocationGridSize.width` as returned by `vkGetPhysicalDeviceMultisamplePropertiesEXT` with a `samples` parameter equaling `rasterizationSamples`
- If no element of the `pDynamicStates` member of `pDynamicState` is `VK_DYNAMIC_STATE_SAMPLE_LOCATIONS_EXT`, and the `sampleLocationsEnable` member of a `VkPipelineSampleLocationsStateCreateInfoEXT` structure included in the `pNext` chain of `pMultisampleState` is `VK_TRUE`, `sampleLocationsInfo.sampleLocationGridSize.height` must evenly divide `VkMultisamplePropertiesEXT::sampleLocationGridSize.height` as returned by `vkGetPhysicalDeviceMultisamplePropertiesEXT` with a `samples` parameter equaling `rasterizationSamples`
- If no element of the `pDynamicStates` member of `pDynamicState` is `VK_DYNAMIC_STATE_SAMPLE_LOCATIONS_EXT`, and the `sampleLocationsEnable` member of a `VkPipelineSampleLocationsStateCreateInfoEXT` structure included in the `pNext` chain of `pMultisampleState` is `VK_TRUE`, `sampleLocationsInfo.sampleLocationsPerPixel` must equal `rasterizationSamples`
- If the `sampleLocationsEnable` member of a `VkPipelineSampleLocationsStateCreateInfoEXT` structure included in the `pNext` chain of `pMultisampleState` is `VK_TRUE`, the fragment shader code must not statically use the extended instruction `InterpolateAtSample`
- `layout` must be consistent with all shaders specified in `pStages`
- If neither the `VK_AMD_mixed_attachment_samples` nor the `VK_NV_framebuffer_mixed_samples` extensions are enabled, and if subpass uses color and/or depth/stencil attachments, then the `rasterizationSamples` member of `pMultisampleState` must be the same as the sample count for those subpass attachments
- If the `VK_AMD_mixed_attachment_samples` extension is enabled, and if subpass uses color and/or depth/stencil attachments, then the `rasterizationSamples` member of `pMultisampleState` must equal the maximum of the sample counts of those subpass attachments
- If the `VK_NV_framebuffer_mixed_samples` extension is enabled, and if subpass has a depth/stencil attachment and depth test, stencil test, or depth bounds test are enabled, then the `rasterizationSamples` member of `pMultisampleState` must be the same as the sample count of the depth/stencil attachment
- If the `VK_NV_framebuffer_mixed_samples` extension is enabled, and if subpass has any color attachments, then the `rasterizationSamples` member of `pMultisampleState` must be greater than or equal to the sample count for those subpass attachments
- If the `VK_NV_coverage_reduction_mode` extension is enabled, the coverage reduction mode specified by `VkPipelineCoverageReductionStateCreateInfoNV::coverageReductionMode`, the `rasterizationSamples` member of `pMultisampleState` and the sample counts for the color and depth/stencil attachments (if the subpass has them) must be a valid combination

- returned by `vkGetPhysicalDeviceSupportedFramebufferMixedSamplesCombinationsNV`
- If `subpass` does not use any color and/or depth/stencil attachments, then the `rasterizationSamples` member of `pMultisampleState` must follow the rules for a zero-attachment subpass
  - `subpass` must be a valid subpass within `renderPass`
  - If the `renderPass` has multiview enabled and `subpass` has more than one bit set in the view mask and `multiviewTessellationShader` is not enabled, then `pStages` must not include tessellation shaders.
  - If the `renderPass` has multiview enabled and `subpass` has more than one bit set in the view mask and `multiviewGeometryShader` is not enabled, then `pStages` must not include a geometry shader.
  - If the `renderPass` has multiview enabled and `subpass` has more than one bit set in the view mask, shaders in the pipeline must not write to the `Layer` built-in output
  - If the `renderPass` has multiview enabled, then all shaders must not include variables decorated with the `Layer` built-in decoration in their interfaces.
  - `flags` must not contain the `VK_PIPELINE_CREATE_DISPATCH_BASE` flag.
  - If `pStages` includes a fragment shader stage and an input attachment was referenced by the `VkRenderPassInputAttachmentAspectCreateInfo` at `renderPass` create time, its shader code must not read from any aspect that was not specified in the `aspectMask` of the corresponding `VkInputAttachmentAspectReference` structure.
  - The number of resources in `layout` accessible to each shader stage that is used by the pipeline must be less than or equal to `VkPhysicalDeviceLimits::maxPerStageResources`
  - If no element of the `pDynamicStates` member of `pDynamicState` is `VK_DYNAMIC_STATE_VIEWPORT_W_SCALING_NV`, and the `viewportWScalingEnable` member of a `VkPipelineViewportWScalingStateCreateInfoNV` structure, included in the `pNext` chain of `pViewportState`, is `VK_TRUE`, the `pViewportWScalings` member of the `VkPipelineViewportWScalingStateCreateInfoNV` must be a pointer to an array of `VkPipelineViewportWScalingStateCreateInfoNV::viewportCount` valid `VkViewportWScalingNV` structures
  - If `pStages` includes a vertex shader stage, `pVertexInputState` must be a valid pointer to a valid `VkPipelineVertexInputStateCreateInfo` structure
  - If `pStages` includes a vertex shader stage, `pInputAssemblyState` must be a valid pointer to a valid `VkPipelineInputAssemblyStateCreateInfo` structure
  - The `Xfb` execution mode can be specified by only one shader stage in `pStages`
  - If any shader stage in `pStages` specifies `Xfb` execution mode it must be the last vertex processing stage
  - If a `VkPipelineRasterizationStateStreamCreateInfoEXT::rasterizationStream` value other than zero is specified, all variables in the output interface of the entry point being compiled decorated with `Position`, `PointSize`, `ClipDistance`, or `CullDistance` must all be decorated with identical `Stream` values that match the `rasterizationStream`
  - If `VkPipelineRasterizationStateStreamCreateInfoEXT::rasterizationStream` is zero, or not specified, all variables in the output interface of the entry point being compiled decorated with `Position`, `PointSize`, `ClipDistance`, or `CullDistance` must all be decorated with a `Stream` value of zero, or must not specify the `Stream` decoration
  - If the last vertex processing stage is a geometry shader, and that geometry shader uses the `GeometryStreams` capability, then `VkPhysicalDeviceTransformFeedbackFeaturesEXT::geometryStreams` feature must be enabled
  - If there are any mesh shader stages in the pipeline there must not be any shader stage in the pipeline with a `Xfb` execution mode.
  - If the `lineRasterizationMode` member of a `VkPipelineRasterizationLineStateCreateInfoEXT` structure included in the `pNext` chain of `pRasterizationState` is `VK_LINE_RASTERIZATION_MODE_BRESENHAM_EXT` or `VK_LINE_RASTERIZATION_MODE_RECTANGULAR_SMOOTH_EXT` and if rasterization is enabled, then the `alphaToCoverageEnable`, `alphaToOneEnable`, and `sampleShadingEnable` members of

- `pMultisampleState` must all be `VK_FALSE`
- If the `stippledLineEnable` member of `VkPipelineRasterizationLineStateCreateInfoEXT` is `VK_TRUE` and no element of the `pDynamicStates` member of `pDynamicState` is `VK_DYNAMIC_STATE_LINE_STIPPLE_EXT`, then the `lineStippleFactor` member of `VkPipelineRasterizationLineStateCreateInfoEXT` must be in the range [1, 256]

## Buffer

Validations for `vkCreateBuffer`:

- If the `flags` member of `pCreateInfo` includes `VK_BUFFER_CREATE_SPARSE_BINDING_BIT`, creating this `VkBuffer` must not cause the total required sparse memory for all currently valid sparse resources on the device to exceed `VkPhysicalDeviceLimits::sparseAddressSpaceSize`

Validations for `VkBufferCreateInfo`:

- `size` must be greater than 0
- If `sharingMode` is `VK_SHARING_MODE_CONCURRENT`, `pQueueFamilyIndices` must be a valid pointer to an array of `queueFamilyIndexCount` `uint32_t` values
- If `sharingMode` is `VK_SHARING_MODE_CONCURRENT`, `queueFamilyIndexCount` must be greater than 1
- If `sharingMode` is `VK_SHARING_MODE_CONCURRENT`, each element of `pQueueFamilyIndices` must be unique and must be less than `pQueueFamilyPropertyCount` returned by either `vkGetPhysicalDeviceQueueFamilyProperties` or `vkGetPhysicalDeviceQueueFamilyProperties2` for the `physicalDevice` that was used to create device
- If the sparse bindings feature is not enabled, `flags` must not contain `VK_BUFFER_CREATE_SPARSE_BINDING_BIT`
- If the sparse buffer residency feature is not enabled, `flags` must not contain `VK_BUFFER_CREATE_SPARSE_RESIDENCY_BIT`
- If the sparse aliased residency feature is not enabled, `flags` must not contain `VK_BUFFER_CREATE_SPARSE_ALIASED_BIT`
- If `flags` contains `VK_BUFFER_CREATE_SPARSE_RESIDENCY_BIT` or `VK_BUFFER_CREATE_SPARSE_ALIASED_BIT`, it must also contain `VK_BUFFER_CREATE_SPARSE_BINDING_BIT`
- If the `pNext` chain includes a `VkExternalMemoryBufferCreateInfo` structure, its `handleTypes` member must only contain bits that are also in `VkExternalBufferProperties::externalMemoryProperties.compatibleHandleTypes`, as returned by `vkGetPhysicalDeviceExternalBufferProperties` with `pExternalBufferInfo->handleType` equal to any one of the handle types specified in `VkExternalMemoryBufferCreateInfo::handleTypes`
- If the protected memory feature is not enabled, `flags` must not contain `VK_BUFFER_CREATE_PROTECTED_BIT`
- If any of the bits `VK_BUFFER_CREATE_SPARSE_BINDING_BIT`, `VK_BUFFER_CREATE_SPARSE_RESIDENCY_BIT`, or `VK_BUFFER_CREATE_SPARSE_ALIASED_BIT` are set, `VK_BUFFER_CREATE_PROTECTED_BIT` must not also be set
- If the `pNext` chain includes a `VkDedicatedAllocationBufferCreateInfoNV` structure, and the `dedicatedAllocation` member of the chained structure is `VK_TRUE`, then `flags` must not include `VK_BUFFER_CREATE_SPARSE_BINDING_BIT`, `VK_BUFFER_CREATE_SPARSE_RESIDENCY_BIT`, or `VK_BUFFER_CREATE_SPARSE_ALIASED_BIT`
- If `VkBufferDeviceAddressCreateInfoEXT::deviceAddress` is not zero, `flags` must include `VK_BUFFER_CREATE_DEVICE_ADDRESS_CAPTURE_REPLAY_BIT`

- If `VkBufferOpaqueCaptureAddressCreateInfo::opaqueCaptureAddress` is not zero, `flags` must include `VK_BUFFER_CREATE_DEVICE_ADDRESS_CAPTURE_REPLAY_BIT`
- If `flags` includes `VK_BUFFER_CREATE_DEVICE_ADDRESS_CAPTURE_REPLAY_BIT`, the `bufferDeviceAddressCaptureReplay` or `VkPhysicalDeviceBufferDeviceAddressFeaturesEXT::bufferDeviceAddressCaptureReplay` feature must be enabled

Validations for `VkBufferViewCreateInfo`:

- `offset` must be less than the size of buffer
- If `range` is not equal to `VK_WHOLE_SIZE`, `range` must be greater than `0`
- If `range` is not equal to `VK_WHOLE_SIZE`, `range` must be an integer multiple of the texel block size of `format`
- If `range` is not equal to `VK_WHOLE_SIZE`, `range` divided by the texel block size of `format`, multiplied by the number of texels per texel block for that format (as defined in the Compatible Formats table), must be less than or equal to `VkPhysicalDeviceLimits::maxTexelBufferElements`
- If `range` is not equal to `VK_WHOLE_SIZE`, the sum of `offset` and `range` must be less than or equal to the size of buffer
- `buffer` must have been created with a `usage` value containing at least one of `VK_BUFFER_USAGE_UNIFORM_TEXEL_BUFFER_BIT` or `VK_BUFFER_USAGE_STORAGE_TEXEL_BUFFER_BIT`
- If `buffer` was created with `usage` containing `VK_BUFFER_USAGE_UNIFORM_TEXEL_BUFFER_BIT`, `format` must be supported for uniform texel buffers, as specified by the `VK_FORMAT_FEATURE_UNIFORM_TEXEL_BUFFER_BIT` flag in `VkFormatProperties::bufferFeatures` returned by `vkGetPhysicalDeviceFormatProperties`
- If `buffer` was created with `usage` containing `VK_BUFFER_USAGE_STORAGE_TEXEL_BUFFER_BIT`, `format` must be supported for storage texel buffers, as specified by the `VK_FORMAT_FEATURE_STORAGE_TEXEL_BUFFER_BIT` flag in `VkFormatProperties::bufferFeatures` returned by `vkGetPhysicalDeviceFormatProperties`
- If `buffer` is non-sparse then it must be bound completely and contiguously to a single `VkDeviceMemory` object
- If the `texelBufferAlignment` feature is not enabled, `offset` must be a multiple of `VkPhysicalDeviceLimits::minTexelBufferOffsetAlignment`
- If the `texelBufferAlignment` feature is enabled and if `buffer` was created with `usage` containing `VK_BUFFER_USAGE_STORAGE_TEXEL_BUFFER_BIT`, `offset` must be a multiple of the lesser of `VkPhysicalDeviceTexelBufferAlignmentPropertiesEXT::storageTexelBufferOffsetAlignmentBytes` or, if `VkPhysicalDeviceTexelBufferAlignmentPropertiesEXT::storageTexelBufferOffsetSingleTexelAlignment` is `VK_TRUE`, the size of a texel of the requested format. If the size of a texel is a multiple of three bytes, then the size of a single component of `format` is used instead
- If the `texelBufferAlignment` feature is enabled and if `buffer` was created with `usage` containing `VK_BUFFER_USAGE_UNIFORM_TEXEL_BUFFER_BIT`, `offset` must be a multiple of the lesser of `VkPhysicalDeviceTexelBufferAlignmentPropertiesEXT::uniformTexelBufferOffsetAlignmentBytes` or, if `VkPhysicalDeviceTexelBufferAlignmentPropertiesEXT::uniformTexelBufferOffsetSingleTexelAlignment` is `VK_TRUE`, the size of a texel of the requested format. If the size of a texel is a multiple of three bytes, then the size of a single component of `format` is used instead

## Image

Validations for `vkCreateImage`:

- If the `Flags` member of `pCreateInfo` includes `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`, creating this `VkImage` must not cause the total required sparse memory for all currently valid sparse resources on the device to exceed `VkPhysicalDeviceLimits::sparseAddressSpaceSize`

Validations for `VkImageCreateInfo`:

- Each of the following values (as described in Image Creation Limits) must not be undefined `imageCreateMaxMipLevels`, `imageCreateMaxArrayLayers`, `imageCreateMaxExtent`, and `imageCreateSampleCounts`.
- If `sharingMode` is `VK_SHARING_MODE_CONCURRENT`, `pQueueFamilyIndices` must be a valid pointer to an array of `queueFamilyIndexCount uint32_t` values
- If `sharingMode` is `VK_SHARING_MODE_CONCURRENT`, `queueFamilyIndexCount` must be greater than 1
- If `sharingMode` is `VK_SHARING_MODE_CONCURRENT`, each element of `pQueueFamilyIndices` must be unique and must be less than `pQueueFamilyPropertyCount` returned by either `vkGetPhysicalDeviceQueueFamilyProperties` or `vkGetPhysicalDeviceQueueFamilyProperties2` for the `physicalDevice` that was used to create device
- If the `pNext` chain includes a `VkExternalFormatANDROID` structure, and its `externalFormat` member is non-zero the `format` must be `VK_FORMAT_UNDEFINED`.
- If the `pNext` chain does not include a `VkExternalFormatANDROID` structure, or does and its `externalFormat` member is 0, the `format` must not be `VK_FORMAT_UNDEFINED`.
- `extent.width` must be greater than 0.
- `extent.height` must be greater than 0.
- `extent.depth` must be greater than 0.
- `mipLevels` must be greater than 0
- `arrayLayers` must be greater than 0
- If `flags` contains `VK_IMAGE_CREATE_CUBE_COMPATIBLE_BIT`, `imageType` must be `VK_IMAGE_TYPE_2D`
- If `flags` contains `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`, `imageType` must be `VK_IMAGE_TYPE_2D`
- If `flags` contains `VK_IMAGE_CREATE_2D_ARRAY_COMPATIBLE_BIT`, `imageType` must be `VK_IMAGE_TYPE_3D`
- `extent.width` must be less than or equal to `imageCreateMaxExtent.width` (as defined in Image Creation Limits).
- `extent.height` must be less than or equal to `imageCreateMaxExtent.height` (as defined in Image Creation Limits).
- `extent.depth` must be less than or equal to `imageCreateMaxExtent.depth` (as defined in Image Creation Limits).
- If `imageType` is `VK_IMAGE_TYPE_2D` and `flags` contains `VK_IMAGE_CREATE_CUBE_COMPATIBLE_BIT`, `extent.width` and `extent.height` must be equal and `arrayLayers` must be greater than or equal to 6
- If `imageType` is `VK_IMAGE_TYPE_1D`, both `extent.height` and `extent.depth` must be 1
- If `imageType` is `VK_IMAGE_TYPE_2D`, `extent.depth` must be 1
- `mipLevels` must be less than or equal to the number of levels in the complete mipmap chain based on `extent.width`, `extent.height`, and `extent.depth`.
- `mipLevels` must be less than or equal to `imageCreateMaxMipLevels` (as defined in Image Creation Limits).
- `arrayLayers` must be less than or equal to `imageCreateMaxArrayLayers` (as defined in Image Creation Limits).

- If `imageType` is `VK_IMAGE_TYPE_3D`, `arrayLayers` must be `1`.
- If `samples` is not `VK_SAMPLE_COUNT_1_BIT`, then `imageType` must be `VK_IMAGE_TYPE_2D`, `flags` must not contain `VK_IMAGE_CREATE_CUBE_COMPATIBLE_BIT`, `mipLevels` must be equal to `1`, and `imageCreateMaybeLinear` (as defined in Image Creation Limits) must be `false`,
- If `samples` is not `VK_SAMPLE_COUNT_1_BIT`, `usage` must not contain `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`
- If `usage` includes `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`, then bits other than `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, and `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT` must not be set
- If `usage` includes `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`, or `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`, `extent.width` must be less than or equal to `VkPhysicalDeviceLimits::maxFramebufferWidth`
- If `usage` includes `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`, or `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`, `extent.height` must be less than or equal to `VkPhysicalDeviceLimits::maxFramebufferHeight`
- If `usage` includes `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`, `extent.width` must be less than or equal to  $\lceil \frac{\text{maxFramebufferWidth}}{\text{minFragmentDensityTexelSize}_{\text{width}}} \rceil$
- If `usage` includes `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`, `extent.height` must be less than or equal to  $\lceil \frac{\text{maxFramebufferHeight}}{\text{minFragmentDensityTexelSize}_{\text{height}}} \rceil$
- If `usage` includes `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`, `usage` must also contain at least one of `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, or `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`.
- `samples` must be a bit value that is set in `imageCreateSampleCounts` (as defined in Image Creation Limits).
- If the multisampled storage images feature is not enabled, and `usage` contains `VK_IMAGE_USAGE_STORAGE_BIT`, `samples` must be `VK_SAMPLE_COUNT_1_BIT`
- If the sparse bindings feature is not enabled, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`
- If the sparse aliased residency feature is not enabled, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_ALIASED_BIT`
- If `imageType` is `VK_IMAGE_TYPE_1D`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
- If the sparse residency for 2D images feature is not enabled, and `imageType` is `VK_IMAGE_TYPE_2D`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
- If the sparse residency for 3D images feature is not enabled, and `imageType` is `VK_IMAGE_TYPE_3D`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
- If the sparse residency for images with 2 samples feature is not enabled, `imageType` is `VK_IMAGE_TYPE_2D`, and `samples` is `VK_SAMPLE_COUNT_2_BIT`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
- If the sparse residency for images with 4 samples feature is not enabled, `imageType` is `VK_IMAGE_TYPE_2D`, and `samples` is `VK_SAMPLE_COUNT_4_BIT`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
- If the sparse residency for images with 8 samples feature is not enabled, `imageType` is `VK_IMAGE_TYPE_2D`, and `samples` is `VK_SAMPLE_COUNT_8_BIT`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
- If the sparse residency for images with 16 samples feature is not enabled, `imageType` is `VK_IMAGE_TYPE_2D`, and `samples` is `VK_SAMPLE_COUNT_16_BIT`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`

- If `flags` contains `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT` or `VK_IMAGE_CREATE_SPARSE_ALIASED_BIT`, it must also contain `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`
- If any of the bits `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`, `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`, or `VK_IMAGE_CREATE_SPARSE_ALIASED_BIT` are set, `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT` must not also be set
- If the protected memory feature is not enabled, `flags` must not contain `VK_IMAGE_CREATE_PROTECTED_BIT`.
- If any of the bits `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`, `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`, or `VK_IMAGE_CREATE_SPARSE_ALIASED_BIT` are set, `VK_IMAGE_CREATE_PROTECTED_BIT` must not also be set.
- If the `pNext` chain includes a `VkExternalMemoryImageCreateInfoNV` structure, it must not contain a `VkExternalMemoryImageCreateInfo` structure.
- If the `pNext` chain includes a `VkExternalMemoryImageCreateInfo` structure, its `handleTypes` member must only contain bits that are also in `VkExternalImageFormatProperties::externalMemoryProperties.compatibleHandleTypes`, as returned by `vkGetPhysicalDeviceImageFormatProperties2` with `format`, `imageType`, `tiling`, `usage`, and `flags` equal to those in this structure, and with a `VkPhysicalDeviceExternalImageFormatInfo` structure included in the `pNext` chain, with a `handleType` equal to any one of the handle types specified in `VkExternalMemoryImageCreateInfo::handleTypes`
- If the `pNext` chain includes a `VkExternalMemoryImageCreateInfoNV` structure, its `handleTypes` member must only contain bits that are also in `VkExternalImageFormatPropertiesNV::externalMemoryProperties.compatibleHandleTypes`, as returned by `vkGetPhysicalDeviceExternalImageFormatPropertiesNV` with `format`, `imageType`, `tiling`, `usage`, and `flags` equal to those in this structure, and with `externalHandleType` equal to any one of the handle types specified in `VkExternalMemoryImageCreateInfoNV::handleTypes`
- If the logical device was created with `VkDeviceGroupDeviceCreateInfo::physicalDeviceCount` equal to 1, `flags` must not contain `VK_IMAGE_CREATE_SPLIT_INSTANCE_BIND_REGIONS_BIT`
- If `flags` contains `VK_IMAGE_CREATE_SPLIT_INSTANCE_BIND_REGIONS_BIT`, then `mipLevels` must be one, `arrayLayers` must be one, `imageType` must be `VK_IMAGE_TYPE_2D`, and `imageCreateMaybeLinear` (as defined in Image Creation Limits) must be false.
- If `flags` contains `VK_IMAGE_CREATE_BLOCK_TEXEL_VIEW_COMPATIBLE_BIT`, then `format` must be a block-compressed image format, an ETC compressed image format, or an ASTC compressed image format.
- If `flags` contains `VK_IMAGE_CREATE_BLOCK_TEXEL_VIEW_COMPATIBLE_BIT`, then `flags` must also contain `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT`.
- `initialLayout` must be `VK_IMAGE_LAYOUT_UNDEFINED` or `VK_IMAGE_LAYOUT_PREINITIALIZED`.
- If the `pNext` chain includes a `VkExternalMemoryImageCreateInfo` or `VkExternalMemoryImageCreateInfoNV` structure:
- If the image `format` is one of those listed in Formats requiring sampler YCBCRconversion for `VK_IMAGE_ASPECT_COLOR_BIT` image views, then `mipLevels` must be 1
- If the image `format` is one of those listed in Formats requiring sampler YCBCRconversion for `VK_IMAGE_ASPECT_COLOR_BIT` image views, `samples` must be `VK_SAMPLE_COUNT_1_BIT`
- If the image `format` is one of those listed in Formats requiring sampler YCBCRconversion for `VK_IMAGE_ASPECT_COLOR_BIT` image views, `imageType` must be `VK_IMAGE_TYPE_2D`
- If the image `format` is one of those listed in Formats requiring sampler YCBCRconversion for `VK_IMAGE_ASPECT_COLOR_BIT` image views, and the `ycbcrImageArrays` feature is not enabled, `arrayLayers` must be 1
- If `format` is a *multi-planar* format, and if `imageCreateFormatFeatures` (as defined in Image Creation Limits) does not contain `VK_FORMAT_FEATURE_DISJOINT_BIT`, then `flags` must not contain `VK_IMAGE_CREATE_DISJOINT_BIT`

- If format is not a *multi-planar* format, and flags does not include `VK_IMAGE_CREATE_ALIAS_BIT`, flags must not contain `VK_IMAGE_CREATE_DISJOINT_BIT`
- If tiling is `VK_IMAGE_TILING_DRM_FORMAT_MODIFIER_EXT`, then the pNext chain must include exactly one of `VkImageDrmFormatModifierListCreateInfoEXT` or `VkImageDrmFormatModifierExplicitCreateInfoEXT` structures
- If the pNext chain includes a `VkImageDrmFormatModifierListCreateInfoEXT` or `VkImageDrmFormatModifierExplicitCreateInfoEXT` structure, then tiling must be `VK_IMAGE_TILING_DRM_FORMAT_MODIFIER_EXT`
- If tiling is `VK_IMAGE_TILING_DRM_FORMAT_MODIFIER_EXT` and flags contains `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT`, then the pNext chain must include a `VkImageFormatListCreateInfo` structure with non-zero `viewFormatCount`.
- If flags contains `VK_IMAGE_CREATE_SAMPLE_LOCATIONS_COMPATIBLE_DEPTH_BIT_EXT` format must be a depth or depth/stencil format
- If the pNext chain includes a `VkExternalMemoryImageCreateInfo` structure whose handleTypes member includes `VK_EXTERNAL_MEMORY_HANDLE_TYPE_ANDROID_HARDWARE_BUFFER_BIT_ANDROID`, imageType must be `VK_IMAGE_TYPE_2D`.
- If the pNext chain includes a `VkExternalMemoryImageCreateInfo` structure whose handleTypes member includes `VK_EXTERNAL_MEMORY_HANDLE_TYPE_ANDROID_HARDWARE_BUFFER_BIT_ANDROID`, mipLevels must either be 1 or equal to the number of levels in the complete mipmap chain based on extent.width, extent.height, and extent.depth.
- If the pNext chain includes a `VkExternalFormatANDROID` structure whose externalFormat member is not 0, flags must not include `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT`.
- If the pNext chain includes a `VkExternalFormatANDROID` structure whose externalFormat member is not 0, usage must not include any usages except `VK_IMAGE_USAGE_SAMPLED_BIT`.
- If the pNext chain includes a `VkExternalFormatANDROID` structure whose externalFormat member is not 0, tiling must be `VK_IMAGE_TILING_OPTIMAL`.
- If format is a depth-stencil format, usage includes `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, and the pNext chain includes a `VkImageStencilUsageCreateInfo` structure, then its `VkImageStencilUsageCreateInfo::stencilUsage` member must also include `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`
- If format is a depth-stencil format, usage does not include `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, and the pNext chain includes a `VkImageStencilUsageCreateInfo` structure, then its `VkImageStencilUsageCreateInfo::stencilUsage` member must also not include `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`
- If format is a depth-stencil format, usage includes `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`, and the pNext chain includes a `VkImageStencilUsageCreateInfo` structure, then its `VkImageStencilUsageCreateInfo::stencilUsage` member must also include `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`
- If format is a depth-stencil format, usage does not include `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`, and the pNext chain includes a `VkImageStencilUsageCreateInfo` structure, then its `VkImageStencilUsageCreateInfo::stencilUsage` member must also not include `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`
- If Format is a depth-stencil format and the pNext chain includes a `VkImageStencilUsageCreateInfo` structure with its `stencilUsage` member including `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`, extent.width must be less than or equal to `VkPhysicalDeviceLimits::maxFramebufferWidth`
- If format is a depth-stencil format and the pNext chain includes a `VkImageStencilUsageCreateInfo` structure with its `stencilUsage` member including `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`, extent.height must be less than or equal to

### `VkPhysicalDeviceLimits::maxFramebufferHeight`

- If the multisampled storage images feature is not enabled, `format` is a depth-stencil format and the `pNext` chain includes a `VkImageStencilUsageCreateInfo` structure with its `stencilUsage` including `VK_IMAGE_USAGE_STORAGE_BIT`, `samples` must be `VK_SAMPLE_COUNT_1_BIT`
- If `flags` contains `VK_IMAGE_CREATE_CORNER_SAMPLED_BIT_NV`, `imageType` must be `VK_IMAGE_TYPE_2D` or `VK_IMAGE_TYPE_3D`
- If `flags` contains `VK_IMAGE_CREATE_CORNER_SAMPLED_BIT_NV`, it must not contain `VK_IMAGE_CREATE_CUBE_COMPATIBLE_BIT` and the `format` must not be a depth/stencil format
- If `flags` contains `VK_IMAGE_CREATE_CORNER_SAMPLED_BIT_NV` and `imageType` is `VK_IMAGE_TYPE_2D`, `extent.width` and `extent.height` must be greater than 1
- If `flags` contains `VK_IMAGE_CREATE_CORNER_SAMPLED_BIT_NV` and `imageType` is `VK_IMAGE_TYPE_3D`, `extent.width`, `extent.height`, and `extent.depth` must be greater than 1
- If `usage` includes `VK_IMAGE_USAGE_SHADING_RATE_IMAGE_BIT_NV`, `imageType` must be `VK_IMAGE_TYPE_2D`.
- If `usage` includes `VK_IMAGE_USAGE_SHADING_RATE_IMAGE_BIT_NV`, `samples` must be `VK_SAMPLE_COUNT_1_BIT`.
- If `usage` includes `VK_IMAGE_USAGE_SHADING_RATE_IMAGE_BIT_NV`, `tiling` must be `VK_IMAGE_TILING_OPTIMAL`.
- If `flags` contains `VK_IMAGE_CREATE_SUBSAMPLED_BIT_EXT`, `tiling` must be `VK_IMAGE_TILING_OPTIMAL`
- If `flags` contains `VK_IMAGE_CREATE_SUBSAMPLED_BIT_EXT`, `imageType` must be `VK_IMAGE_TYPE_2D`
- If `flags` contains `VK_IMAGE_CREATE_SUBSAMPLED_BIT_EXT`, `flags` must not contain `VK_IMAGE_CREATE_CUBE_COMPATIBLE_BIT`
- If `flags` contains `VK_IMAGE_CREATE_SUBSAMPLED_BIT_EXT`, `mipLevels` must be 1

### Validations for `VkImageViewCreateInfo`:

- If `image` was not created with `VK_IMAGE_CREATE_CUBE_COMPATIBLE_BIT` then `viewType` must not be `VK_IMAGE_VIEW_TYPE_CUBE` or `VK_IMAGE_VIEW_TYPE_CUBE_ARRAY`
- If the image cubemap arrays feature is not enabled, `viewType` must not be `VK_IMAGE_VIEW_TYPE_CUBE_ARRAY`
- If `image` was created with `VK_IMAGE_TYPE_3D` but without `VK_IMAGE_CREATE_2D_ARRAY_COMPATIBLE_BIT` set then `viewType` must not be `VK_IMAGE_VIEW_TYPE_2D` or `VK_IMAGE_VIEW_TYPE_2D_ARRAY`
- `image` must have been created with a `usage` value containing at least one of `VK_IMAGE_USAGE_SAMPLED_BIT`, `VK_IMAGE_USAGE_STORAGE_BIT`, `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_SHADING_RATE_IMAGE_BIT_NV`, or `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`
- The format features of the resultant image view must contain at least one bit.
- If `usage` contains `VK_IMAGE_USAGE_SAMPLED_BIT`, then the format features of the resultant image view must contain `VK_FORMAT_FEATURE_SAMPLED_IMAGE_BIT`.
- If `usage` contains `VK_IMAGE_USAGE_STORAGE_BIT`, then the image view's format features must contain `VK_FORMAT_FEATURE_STORAGE_IMAGE_BIT`.
- If `usage` contains `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`, then the image view's format features must contain `VK_FORMAT_FEATURE_COLOR_ATTACHMENT_BIT`.
- If `usage` contains `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, then the image view's format features must contain `VK_FORMAT_FEATURE_DEPTH_STENCIL_ATTACHMENT_BIT`.
- If `usage` contains `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`, then the image view's format features must contain at least one of `VK_FORMAT_FEATURE_COLOR_ATTACHMENT_BIT` or `VK_FORMAT_FEATURE_DEPTH_STENCIL_ATTACHMENT_BIT`.
- `subresourceRange.baseMipLevel` must be less than the `mipLevels` specified in

- `VkImageCreateInfo` when `image` was created
- If `subresourceRange.levelCount` is not `VK_REMAINING_MIP_LEVELS`, `subresourceRange.baseMipLevel+subresourceRange.levelCount` must be less than or equal to the `mipLevels` specified in `VkImageCreateInfo` when `image` was created
  - If `image` was created with `usage` containing `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`, `subresourceRange.levelCount` must be 1
  - If `image` is not a 3D image created with `VK_IMAGE_CREATE_2D_ARRAY_COMPATIBLE_BIT` set, or `viewType` is not `VK_IMAGE_VIEW_TYPE_2D` or `VK_IMAGE_VIEW_TYPE_2D_ARRAY`, `subresourceRange.baseArrayLayer` must be less than the `arrayLayers` specified in `VkImageCreateInfo` when `image` was created
  - If `subresourceRange.layerCount` is not `VK_REMAINING_ARRAY_LAYERS`, `image` is not a 3D image created with `VK_IMAGE_CREATE_2D_ARRAY_COMPATIBLE_BIT` set, or `viewType` is not `VK_IMAGE_VIEW_TYPE_2D` or `VK_IMAGE_VIEW_TYPE_2D_ARRAY`, `subresourceRange.layerCount` must be non-zero and `subresourceRange.baseArrayLayer+subresourceRange.layerCount` must be less than or equal to the `arrayLayers` specified in `VkImageCreateInfo` when `image` was created
  - If `image` is a 3D image created with `VK_IMAGE_CREATE_2D_ARRAY_COMPATIBLE_BIT` set, and `viewType` is `VK_IMAGE_VIEW_TYPE_2D` or `VK_IMAGE_VIEW_TYPE_2D_ARRAY`, `subresourceRange.baseArrayLayer` must be less than the depth computed from `baseMipLevel` and `extent.depth` specified in `VkImageCreateInfo` when `image` was created, according to the formula defined in Image Miplevel Sizing.
  - If `subresourceRange.layerCount` is not `VK_REMAINING_ARRAY_LAYERS`, `image` is a 3D image created with `VK_IMAGE_CREATE_2D_ARRAY_COMPATIBLE_BIT` set, and `viewType` is `VK_IMAGE_VIEW_TYPE_2D` or `VK_IMAGE_VIEW_TYPE_2D_ARRAY`, `subresourceRange.layerCount` must be non-zero and `subresourceRange.baseArrayLayer+subresourceRange.layerCount` must be less than or equal to the depth computed from `baseMipLevel` and `extent.depth` specified in `VkImageCreateInfo` when `image` was created, according to the formula defined in Image Miplevel Sizing.
  - If `image` was created with the `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT` flag, `format` must be compatible with the `format` used to create `image`, as defined in Format Compatibility Classes
  - If `image` was created with the `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT` flag, but without the `VK_IMAGE_CREATE_BLOCK_TEXEL_VIEW_COMPATIBLE_BIT` flag, and if the `format` of the `image` is not a multi-planar format, `format` must be compatible with the `format` used to create `image`, as defined in Format Compatibility Classes
  - If `image` was created with the `VK_IMAGE_CREATE_BLOCK_TEXEL_VIEW_COMPATIBLE_BIT` flag, `format` must be compatible with, or must be an uncompressed format that is size-compatible with, the `format` used to create `image`.
  - If `image` was created with the `VK_IMAGE_CREATE_BLOCK_TEXEL_VIEW_COMPATIBLE_BIT` flag, the `levelCount` and `layerCount` members of `subresourceRange` must both be 1.
  - If a `VkImageFormatListCreateInfo` structure was included in the `pNext` chain of the `VkImageCreateInfo` structure used when creating `image` and the `viewFormatCount` field of `VkImageFormatListCreateInfo` is not zero then `format` must be one of the formats in `VkImageFormatListCreateInfo::pViewFormats`.
  - If `image` was created with the `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT` flag, if the `format` of the `image` is a multi-planar format, and if `subresourceRange.aspectMask` is one of `VK_IMAGE_ASPECT_PLANE_0_BIT`, `VK_IMAGE_ASPECT_PLANE_1_BIT`, or `VK_IMAGE_ASPECT_PLANE_2_BIT`, then `format` must be compatible with the `VkFormat` for the plane of the `image` format indicated by `subresourceRange.aspectMask`, as defined in Compatible formats of planes of multi-planar formats
  - If `image` was not created with the `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT` flag, or if the `format` of the `image` is a multi-planar format and if `subresourceRange.aspectMask` is `VK_IMAGE_ASPECT_COLOR_BIT`, `format` must be identical to the `format` used to create `image`
  - If the `pNext` chain includes a `VkSamplerYcbcrConversionInfo` structure with a conversion

- value other than `VK_NULL_HANDLE`, all members of `components` must have the value `VK_COMPONENT_SWIZZLE_IDENTITY`.
- If `image` is non-sparse then it must be bound completely and contiguously to a single `VkDeviceMemory` object
  - `subresourceRange` and `viewType` must be compatible with the `image`, as described in the compatibility table
  - If `image` has an external format, `format` must be `VK_FORMAT_UNDEFINED`.
  - If `image` has an external format, the `pNext` chain must include a `VkSamplerYcbcrConversionInfo` structure with a `conversion` object created with the same external format as `image`.
  - If `image` has an external format, all members of `components` must be `VK_COMPONENT_SWIZZLE_IDENTITY`.
  - If `image` was created with `usage` containing `VK_IMAGE_USAGE_SHADING_RATE_IMAGE_BIT_NV`, `viewType` must be `VK_IMAGE_VIEW_TYPE_2D` or `VK_IMAGE_VIEW_TYPE_2D_ARRAY`
  - If `image` was created with `usage` containing `VK_IMAGE_USAGE_SHADING_RATE_IMAGE_BIT_NV`, `format` must be `VK_FORMAT_R8_UINT`
  - If dynamic fragment density map feature is not enabled, `flags` must not contain `VK_IMAGE_CREATE_FRAGMENT_DENSITY_MAP_DYNAMIC_BIT_EXT`
  - If dynamic fragment density map feature is not enabled and `image` was created with `usage` containing `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`, `flags` must not contain any of `VK_IMAGE_CREATE_PROTECTED_BIT`, `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`, `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`, or `VK_IMAGE_CREATE_SPARSE_ALIASED_BIT`
  - If the `pNext` chain includes a `VkImageViewUsageCreateInfo` structure, and `image` was not created with a `VkImageStencilUsageCreateInfo` structure included in the `pNext` chain of `VkImageCreateInfo`, its `usage` member must not include any bits that were not set in the `usage` member of the `VkImageCreateInfo` structure used to create `image`
  - If the `pNext` chain includes a `VkImageViewUsageCreateInfo` structure, `image` was created with a `VkImageStencilUsageCreateInfo` structure included in the `pNext` chain of `VkImageCreateInfo`, and `subResourceRange.aspectMask` includes `VK_IMAGE_ASPECT_STENCIL_BIT`, the `usage` member of the `VkImageViewUsageCreateInfo` instance must not include any bits that were not set in the `usage` member of the `VkImageStencilUsageCreateInfo` structure used to create `image`
  - If the `pNext` chain includes a `VkImageViewUsageCreateInfo` structure, `image` was created with a `VkImageStencilUsageCreateInfo` structure included in the `pNext` chain of `VkImageCreateInfo`, and `subResourceRange.aspectMask` includes bits other than `VK_IMAGE_ASPECT_STENCIL_BIT`, the `usage` member of the `VkImageViewUsageCreateInfo` structure must not include any bits that were not set in the `usage` member of the `VkImageCreateInfo` structure used to create `image`

Validations for `VkImageSubresourceRange`:

- If `levelCount` is not `VK_REMAINING_MIP_LEVELS`, it must be greater than `0`
- If `layerCount` is not `VK_REMAINING_ARRAY_LAYERS`, it must be greater than `0`
- If `aspectMask` includes `VK_IMAGE_ASPECT_COLOR_BIT`, then it must not include any of `VK_IMAGE_ASPECT_PLANE_0_BIT`, `VK_IMAGE_ASPECT_PLANE_1_BIT`, or `VK_IMAGE_ASPECT_PLANE_2_BIT`
- `aspectMask` must not include `VK_IMAGE_ASPECT_MEMORY_PLANE_i_BIT_EXT` for any index `i`

## Descriptor layout

Validations for `VkDescriptorSetLayoutCreateInfo`:

- The `VkDescriptorSetLayoutBinding::binding` members of the elements of the `pBindings` array must each have different values.
- If `flags` contains `VK_DESCRIPTOR_SET_LAYOUT_CREATE_PUSH_DESCRIPTOR_BIT_KHR`, then all elements of `pBindings` must not have a `descriptorType` of `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC` or `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC`
- If `flags` contains `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT_KHR`, then all elements of `pBindings` must not have a `descriptorType` of `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT`
- If `flags` contains `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_DESCRIPTOR_BIT_KHR`, then the total number of elements of all bindings must be less than or equal to `VkPhysicalDevicePushDescriptorPropertiesKHR::maxPushDescriptors`
- If any binding has the `VK_DESCRIPTOR_BINDING_UPDATE_AFTER_BIND_BIT` bit set, `flags` must include `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT`
- If any binding has the `VK_DESCRIPTOR_BINDING_UPDATE_AFTER_BIND_BIT` bit set, then all bindings must not have `descriptorType` of `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC` or `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC`

Validations for `VkDescriptorSetLayoutBinding`:

- If `descriptorType` is `VK_DESCRIPTOR_TYPE_SAMPLER` or `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, and `descriptorCount` is not 0 and `pImmutableSamplers` is not NULL, `pImmutableSamplers` must be a valid pointer to an array of `descriptorCount` valid `VkSampler` handles
- If `descriptorType` is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT` then `descriptorCount` must be a multiple of 4
- If `descriptorType` is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT` then `descriptorCount` must be less than or equal to `VkPhysicalDeviceInlineUniformBlockPropertiesEXT::maxInlineUniformBlockSize`
- If `descriptorCount` is not 0, `stageFlags` must be a valid combination of `VkShaderStageFlagBits` values
- If `descriptorType` is `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT` and `descriptorCount` is not 0, then `stageFlags` must be 0 or `VK_SHADER_STAGE_FRAGMENT_BIT`

Validations for `VkPipelineLayoutCreateInfo`:

- `setLayoutCount` must be less than or equal to `VkPhysicalDeviceLimits::maxBoundDescriptorSets`
- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_SAMPLER` and `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxPerStageDescriptorSamplers`
- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER` and `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxPerStageDescriptorUniformBuffers`
- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER` and `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC` accessible to any given shader stage across

all elements of pSetLayouts must be less than or equal to

VkPhysicalDeviceLimits::maxPerStageDescriptorStorageBuffers

- The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_COMBINED\_IMAGE\_SAMPLER, VK\_DESCRIPTOR\_TYPE\_SAMPLED\_IMAGE, and VK\_DESCRIPTOR\_TYPE\_UNIFORM\_TEXEL\_BUFFER accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to VkPhysicalDeviceLimits::maxPerStageDescriptorSampledImages
- The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_STORAGE\_IMAGE, and VK\_DESCRIPTOR\_TYPE\_STORAGE\_TEXEL\_BUFFER accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to VkPhysicalDeviceLimits::maxPerStageDescriptorStorageImages
- The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_INPUT\_ATTACHMENT accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to VkPhysicalDeviceLimits::maxPerStageDescriptorInputAttachments
- The total number of bindings in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_INLINE\_UNIFORM\_BLOCK\_EXT accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to VkPhysicalDeviceInlineUniformBlockPropertiesEXT::maxPerStageDescriptorInlineUniformBlocks
- The total number of descriptors with a descriptorType of VK\_DESCRIPTOR\_TYPE\_SAMPLER and VK\_DESCRIPTOR\_TYPE\_COMBINED\_IMAGE\_SAMPLER accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindSamplers
- The total number of descriptors with a descriptorType of VK\_DESCRIPTOR\_TYPE\_UNIFORM\_BUFFER and VK\_DESCRIPTOR\_TYPE\_UNIFORM\_BUFFER\_DYNAMIC accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindUniformBuffer
- The total number of descriptors with a descriptorType of VK\_DESCRIPTOR\_TYPE\_STORAGE\_BUFFER and VK\_DESCRIPTOR\_TYPE\_STORAGE\_BUFFER\_DYNAMIC accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindStorageBuffer
- The total number of descriptors with a descriptorType of VK\_DESCRIPTOR\_TYPE\_COMBINED\_IMAGE\_SAMPLER, VK\_DESCRIPTOR\_TYPE\_SAMPLED\_IMAGE, and VK\_DESCRIPTOR\_TYPE\_UNIFORM\_TEXEL\_BUFFER accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindSampledImage
- The total number of descriptors with a descriptorType of VK\_DESCRIPTOR\_TYPE\_STORAGE\_IMAGE, and VK\_DESCRIPTOR\_TYPE\_STORAGE\_TEXEL\_BUFFER accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindStorageTexelBuffer
- The total number of descriptors with a descriptorType of VK\_DESCRIPTOR\_TYPE\_INPUT\_ATTACHMENT accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindInputAttachment
- The total number of bindings with a descriptorType of VK\_DESCRIPTOR\_TYPE\_INLINE\_UNIFORM\_BLOCK\_EXT accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to

- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_SAMPLER` and `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxDescriptorSetSamplers`
- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxDescriptorSetUniformBuffers`
- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxDescriptorSetUniformBuffersDynamic`
- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxDescriptorSetStorageBuffers`
- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxDescriptorSetStorageBuffersDynamic`
- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, `VK_DESCRIPTOR_TYPE_SAMPLED_IMAGE`, and `VK_DESCRIPTOR_TYPE_UNIFORM_TEXEL_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxDescriptorSetSampledImages`
- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_STORAGE_IMAGE`, and `VK_DESCRIPTOR_TYPE_STORAGE_TEXEL_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxDescriptorSetStorageImages`
- The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxDescriptorSetInputAttachments`
- The total number of bindings in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceInlineUniformBlockPropertiesEXT::maxDescriptorSetInlineUniformBlocks`
- The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_SAMPLER` and `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindSamplers`
- The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindUniformBuffers`

- The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindUniformBuffers`
- The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindStorageBuffers`
- The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindStorageBuffers`
- The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, `VK_DESCRIPTOR_TYPE_SAMPLED_IMAGE`, and `VK_DESCRIPTOR_TYPE_UNIFORM_TEXEL_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindSampledImages`
- The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_STORAGE_IMAGE`, and `VK_DESCRIPTOR_TYPE_STORAGE_TEXEL_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindStorageImages`
- The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindInputAttachments`
- The total number of bindings with a descriptorType of `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceInlineUniformBlockPropertiesEXT::maxDescriptorSetUpdateAfterBindInlineUniformBlocks`
- Any two elements of `pPushConstantRanges` must not include the same stage in `stageFlags`
- `pSetLayouts` must not contain more than one descriptor set layout that was created with `VK_DESCRIPTOR_SET_LAYOUT_CREATE_PUSH_DESCRIPTOR_BIT_KHR` set
- The total number of bindings with a descriptorType of `VK_DESCRIPTOR_TYPE_ACCELERATION_STRUCTURE_NV` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceRayTracingPropertiesNV::maxDescriptorSetAccelerationStructures`

Validations for `VkPushConstantRange`:

- `offset` must be less than `VkPhysicalDeviceLimits::maxPushConstantsSize`
- `offset` must be a multiple of 4
- `size` must be greater than 0
- `size` must be a multiple of 4
- `size` must be less than or equal to `VkPhysicalDeviceLimits::maxPushConstantsSize` minus `offset`

## Descriptor set

Validations for `VkDescriptorPoolCreateInfo`:

- `maxSets` must be greater than 0

Validations for `VkDescriptorPoolSize`:

- `descriptorCount` must be greater than 0
- If type is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT` then `descriptorCount` must be a multiple of 4

Validations for `VkDescriptorSetAllocateInfo`:

- Each element of `pSetLayouts` must not have been created with `VK_DESCRIPTOR_SET_LAYOUT_CREATE_PUSH_DESCRIPTOR_BIT_KHR` set
- If any element of `pSetLayouts` was created with the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set, `descriptorPool` must have been created with the `VK_DESCRIPTOR_POOL_CREATE_UPDATE_AFTER_BIND_BIT` flag set

Validations for `VkDescriptorSetVariableDescriptorCountAllocateInfo`:

- If `descriptorSetCount` is not zero, `descriptorSetCount` must equal `VkDescriptorSetAllocateInfo::descriptorSetCount`
- If `VkDescriptorSetAllocateInfo::pSetLayouts[i]` has a variable descriptor count binding, then `pDescriptorCounts[i]` must be less than or equal to the descriptor count specified for that binding when the descriptor set layout was created.

## Semaphore

Validations for `VkSemaphoreTypeCreateInfo`:

- If the timelineSemaphore feature is not enabled, `semaphoreType` must not equal `VK_SEMAPHORE_TYPE_TIMELINE`
- If `semaphoreType` is `VK_SEMAPHORE_TYPE_BINARY`, `initialValue` must be zero.
  - Handled by API design

## Queue

Validations for `vkQueueSubmit`:

- If `fence` is not `VK_NULL_HANDLE`, `fence` must be unsignaled
- If `fence` is not `VK_NULL_HANDLE`, `fence` must not be associated with any other queue command that has not yet completed execution on that queue
- Any calls to `vkCmdSetEvent`, `vkCmdResetEvent` or `vkCmdWaitEvents` that have been recorded into any of the command buffer elements of the `pCommandBuffers` member of any element of `pSubmits`, must not reference any `VkEvent` that is referenced by any of those commands in a command buffer that has been submitted to another queue and is still in the *pending state*
- Any stage flag included in any element of the `pWaitDstStageMask` member of any element of `pSubmits` must be a pipeline stage supported by one of the capabilities of `queue`, as specified in the table of supported pipeline stages
- Each element of the `pSignalSemaphores` member of any element of `pSubmits` must be unsignaled when the semaphore signal operation it defines is executed on the device
- When a semaphore wait operation referring to a binary semaphore defined by any element of the `pWaitSemaphores` member of any element of `pSubmits` executes on `queue`, there must be no other queues waiting on the same semaphore
- All elements of the `pWaitSemaphores` member of all elements of `pSubmits` created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_BINARY` must reference a semaphore signal operation that has been submitted for execution and any semaphore signal operations on which it

- depends (if any) must have also been submitted for execution
- Each element of the `pCommandBuffers` member of each element of `pSubmits` must be in the pending or executable state
  - If any element of the `pCommandBuffers` member of any element of `pSubmits` was not recorded with the `VK_COMMAND_BUFFER_USAGE_SIMULTANEOUS_USE_BIT`, it must not be in the pending state
  - Any secondary command buffers recorded into any element of the `pCommandBuffers` member of any element of `pSubmits` must be in the pending or executable state
  - If any secondary command buffers recorded into any element of the `pCommandBuffers` member of any element of `pSubmits` was not recorded with the `VK_COMMAND_BUFFER_USAGE_SIMULTANEOUS_USE_BIT`, it must not be in the pending state
  - Each element of the `pCommandBuffers` member of each element of `pSubmits` must have been allocated from a `VkCommandPool` that was created for the same queue family `queue` belongs to
  - If any element of `pSubmits`→`pCommandBuffers` includes a Queue Family Transfer Acquire Operation, there must exist a previously submitted Queue Family Transfer Release Operation on a queue in the queue family identified by the acquire operation, with parameters matching the acquire operation as defined in the definition of such acquire operations, and which happens before the acquire operation
  - If a command recorded into any element of `pCommandBuffers` was a `vkCmdBeginQuery` whose `queryPool` was created with a `queryType` of `VK_QUERY_TYPE_PERFORMANCE_QUERY_KHR`, the profiling lock must have been held continuously on the `VkDevice` that `queue` was retrieved from, throughout recording of those command buffers
  - Any resource created with `VK_SHARING_MODE_EXCLUSIVE` that is read by an operation specified by `pSubmits` must not be owned by any queue family other than the one which `queue` belongs to, at the time it is executed

Validations for `VkSubmitInfo`:

- Each element of `pCommandBuffers` must not have been allocated with `VK_COMMAND_BUFFER_LEVEL_SECONDARY`
- If the geometry shaders feature is not enabled, each element of `pWaitDstStageMask` must not contain `VK_PIPELINE_STAGE_GEOMETRY_SHADER_BIT`
- If the tessellation shaders feature is not enabled, each element of `pWaitDstStageMask` must not contain `VK_PIPELINE_STAGE_TESSELLATION_CONTROL_SHADER_BIT` or `VK_PIPELINE_STAGE_TESSELLATION_EVALUATION_SHADER_BIT`
- Each element of `pWaitDstStageMask` must not include `VK_PIPELINE_STAGE_HOST_BIT`.
- If any element of `pWaitSemaphores` or `pSignalSemaphores` was created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_TIMELINE`, then the `pNext` chain must include a `VkTimelineSemaphoreSubmitInfo` structure
- If the `pNext` chain of this structure includes a `VkTimelineSemaphoreSubmitInfo` structure and any element of `pWaitSemaphores` was created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_TIMELINE`, then its `waitSemaphoreValueCount` member must equal `waitSemaphoreCount`
- If the `pNext` chain of this structure includes a `VkTimelineSemaphoreSubmitInfo` structure and any element of `pSignalSemaphores` was created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_TIMELINE`, then its `signalSemaphoreValueCount` member must equal `signalSemaphoreCount`
- For each element of `pSignalSemaphores` created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_TIMELINE` the corresponding element of `VkTimelineSemaphoreSubmitInfo::pSignalSemaphoreValues` must have a value greater than the current value of the semaphore when the semaphore signal operation is executed
- For each element of `pWaitSemaphores` created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_TIMELINE` the corresponding element of `VkTimelineSemaphoreSubmitInfo::pWaitSemaphoreValues` must have a value which does not differ from the current value of the semaphore or the value of any outstanding semaphore wait or

- signal operation on that semaphore by more than `maxTimelineSemaphoreValueDifference`.
- For each element of `pSignalSemaphores` created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_TIMELINE` the corresponding element of `VkTimelineSemaphoreSubmitInfo::pSignalSemaphoreValues` must have a value which does not differ from the current value of the semaphore or the value of any outstanding semaphore wait or signal operation on that semaphore by more than `maxTimelineSemaphoreValueDifference`.
  - If the mesh shaders feature is not enabled, each element of `pWaitDstStageMask` must not contain `VK_PIPELINE_STAGE_MESH_SHADER_BIT_NV`
  - If the task shaders feature is not enabled, each element of `pWaitDstStageMask` must not contain `VK_PIPELINE_STAGE_TASK_SHADER_BIT_NV`

Validations for `VkPresentInfoKHR`:

- Each element of `pImageIndices` must be the index of a presentable image acquired from the swapchain specified by the corresponding element of the `pSwapchains` array, and the presented image subresource must be in the `VK_IMAGE_LAYOUT_PRESENT_SRC_KHR` or `VK_IMAGE_LAYOUT_SHARED_PRESENT_KHR` layout at the time the operation is executed on a `VkDevice`
- All elements of the `pWaitSemaphores` must have a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_BINARY`