Vulkanised 2026
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Learning Vulkan Independently

Caden Lafollette
Graduate Student
East Tennessee State University

Who I Am

- I finished my Bachelor's in Computer Science in the Spring of 2025
- I am currently pursuing a Master of Fine Arts in Digital Media, focusing on 3D animation rendering
- I aim to pursue a PhD in Computer Science after finishing my MFA

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My Vulkan Background

- I wrote a small Vulkan renderer as part of an independent study course (my intro to 3D graphics!)
- I’ve continued to use and extend this renderer as part of my research on 3D animation rendering

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Why This Talk?

- Aimed towards undergraduate and graduate students (or really anyone learning independently)
- Many universities do not provide resources for learning Vulkan, at least not directly

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Why This Talk?

- This isn’t meant to be a tutorial, but more so a “what you can expect”
- The ideal takeaway is the ability to approach learning Vulkan with intent and forethought

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Agenda

- Before Starting
- Getting Started
- I’ve Got a Triangle…
- …so What’s Next?
- Struggle Points & Timeframes

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Before You Start

- Most tutorials will introduce a lot of new information all at the same time
- It can be very easy to lose sight of what you originally set out to learn

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Before You Start

- Vulkan expects a solid background in:
  - Operating Systems / Computer Systems
  - Computer Graphics / 3D Math
  - Using external libraries
  - … just to name a few

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Important OS Topics

- Concurrency
  - Synchronous vs. asynchronous function calls
  - Synchronization primitives (semaphores, barriers, fences)
  - Conditions for deadlock
- Memory allocation
  - CPU vs. GPU memory

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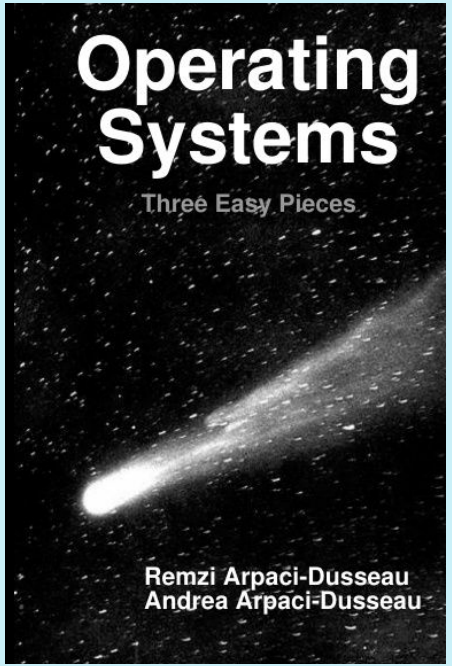
Helpful Resource

Operating Systems: Three Easy Pieces

Remzi H. Arpaci-Dusseau & Andrea C. Arpaci-Dusseau



“Concurrency” section (Chapters 24 - 35).

https://pages.cs.wisc.edu/~remzi/OSTEP/

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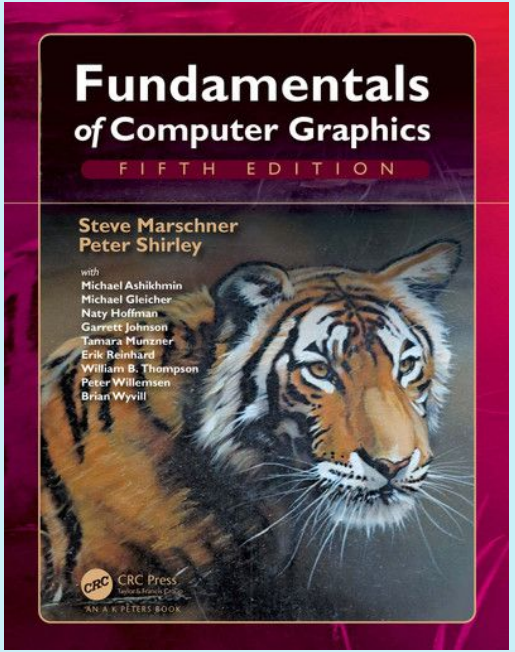
Important CG Topics

- The Graphics Pipeline
    - Fixed vs. Programmable shader stages
- Shading Languages (GLSL, HLSL, etc)
    - Keywords: layout, set, binding
    - Different resource types

Helpful Resource

Fundamentals of Computer Graphics, 5th Edition

Steve Marschner & Peter Shirley



“Miscellaneous Math” section (Chapter 2)
“Graphics Pipeline” section (Chapter 9)

https://learning.oreilly.com/library/view/fundamentals-of-computer/9781000426359/

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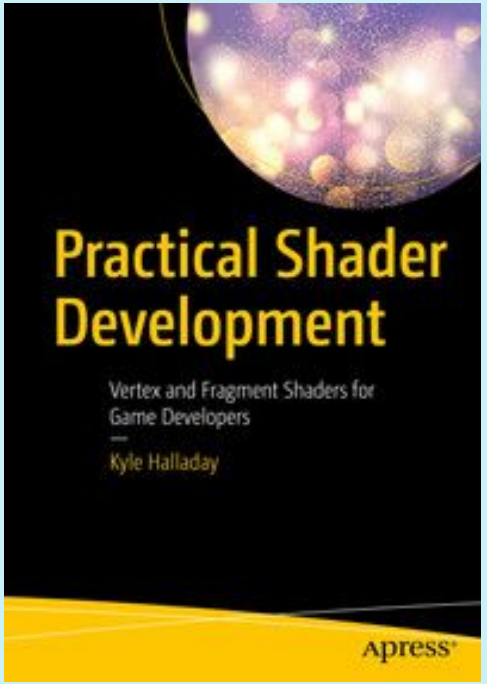
Helpful Resource

Practical Shader Development

Kyle Halladay



https://learning.oreilly.com/library/view/practical-shader-development/9781484244579/

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Before You Start - Libraries

- Using libraries in your project (mostly) makes your life easier, but they always come with a cost
- You need to learn that specific library, read it's documentation, include it in your build process, solve the occasional linkage error, etc

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Before You Start - Libraries

- Some libraries are “non-negotiable”, or incredibly necessary
- Window libraries such as GLFW or SDL3
    - GLFW
    - SDL3
- Math libraries such as GLM
    - GLM

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Before You Start - Libraries

- I recommend trying to minimize the amount of libraries that you use when learning to avoid getting overwhelmed
- *Most* single-source and single-header libraries are safe enough to include without much overhead

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Misc. Helpful Libraries

stb, tinyobj, tinygltf, ufbx (Asset importers)

NVIDIA NSight (Not a library, but a Visual Studio extension!)

DearImGui (Lightweight UI)

ImGuizmo (DearImGui extension for game-engine like Gizmos)

imnodes (DearImGui extension for node-based UI)

Important Consideration

Should you learn Vulkan as your first graphics API?

- Maybe…?
- If you have no 3D programming experience, you will be learning more than one thing at time
- But it can be done!

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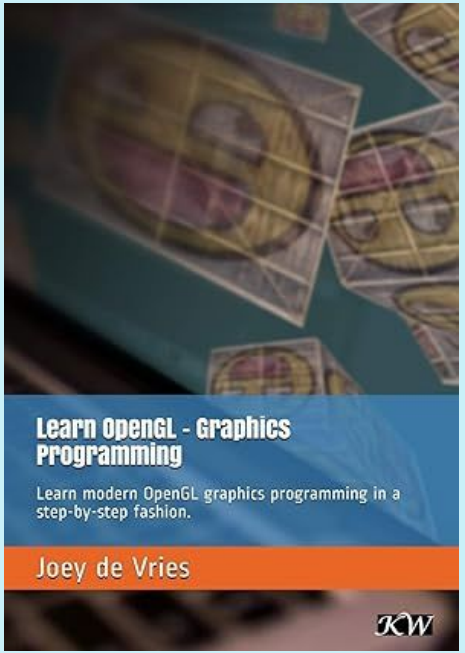
Helpful Resource

Learn OpenGL

Joey de Vries



Web:
https://learnopengl.com/Introduction

Print:
https://www.amazon.com/gp/product/9090332561/ref=as_li_tl?tag=joeydevries

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Getting Started

- Lots of options for getting started

vulkan-tutorial.com (Alexander Overvoorde, 2016)

Vulkan Video Series (Brendan Galea, 2021)

Vulkan for Beginners (OGLDev, 2024)

Khronos Vulkan Tutorial (Khronos Group)

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Getting Started

- How to decide?
- Tutorials from 2016 are based on Vulkan 1.0
- Newer tutorials are still based on “vulkan-tutorial.com”, but include support for “modern” Vulkan

Getting Started

- Many libraries offer support for getting started more quickly

Vulkan-Hpp (Khronos Group)

Vulkan Memory Allocator, or VMA (AMD)

- You can also find many “Starter Projects” that aim to reduce the overhead of getting started (I do not recommend these).

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Getting Started

- In short, there are more than a few ways to get started
- Don’t worry about picking the “right” or “best” version as there are always trade-offs
- Be wary of libraries that have little-to-no external support

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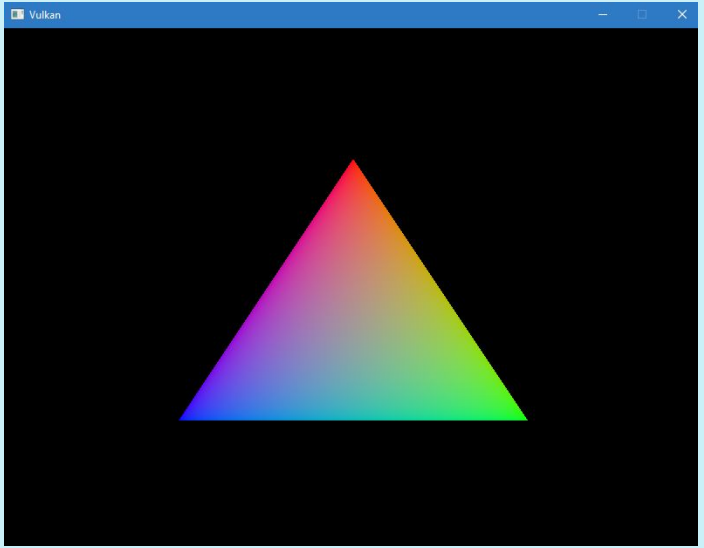
I've Got a Triangle...

- You've written about ~700 lines of code for... not much.



- But it's a start!

- At this point, you've been exposed to many of Vulkan's core features.

...so What's Next?

- Identify an area of computer graphics that interests you!
    - 3D Lighting / Shadows
    - 3D Animation
    - 2D Rendering
    - ...or anything else!

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Helpful Resources

Common Mistakes When Learning Vulkan (Charles Giessen, 2024)

Multiple Object Rendering in Vulkan (Vasif Abdullayev, 2020)

Sascha Willems Vulkan Examples (Sascha Willems)

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Identifying Struggle Points

- How do you identify what you know? (Or Don't)

- How do you get the "big picture"?

What You Know (or Don't)

- By following tutorials, you will generally reach some form of "milestone"
    - First triangle, first 3D model, etc

- Work to identify what you know by making changes
    - How would you draw 2 triangles? (or 2 3D models)
    - What do you need to change to modify the appearance of things seen on screen? (Color, size, orientation, etc)

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When You *Don't* Know

- Lots of moving parts, so it can be tricky to identify the right problem

- Making changes often involves:
  - Writing or updating shader code
  - Modifying your graphics pipeline layout
  - Changing values stored in buffer objects
  - Fixing an existing bug in your project
  - …among others

When You *Don't* Know

- Unfortunately, there isn't really a "one-size-fits-all" way to identify what you don't know, but…
    - Understanding Vulkan Validation Errors
    - Using debug tools
    - Reading documentation
    - Researching common Vulkan issues

…is a great toolkit to have!

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When You *Do* Know

- Congrats! You now have confirmation that you have learned something
- Use the “A-ha!” moments to build a foundation of what you *DO* know and reinforce what you have done so far
- Being able to identify what you know will help ask better questions and learn what you *DON’T* know

The “Big Picture”

- With as much as there is to learn, it can be difficult to identify key takeaways

- To me, understanding VkGraphicsPipeline objects is the closest you can get to understanding the “core” of how Vulkan works at a high level

  See: https://docs.vulkan.org/refpages/latest/refpages/source/VkGraphicsPipelineCreateInfo.html

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The “Big Picture”

- VkGraphicsPipeline objects represent lots of the major pieces of a running Vulkan application
- Being able to understand what each component stores and the function it serves helps lead to a larger scale of what Vulkan is meant to do
- It also helps lead to meaningful questions you can ask about how things work when you aren’t sure

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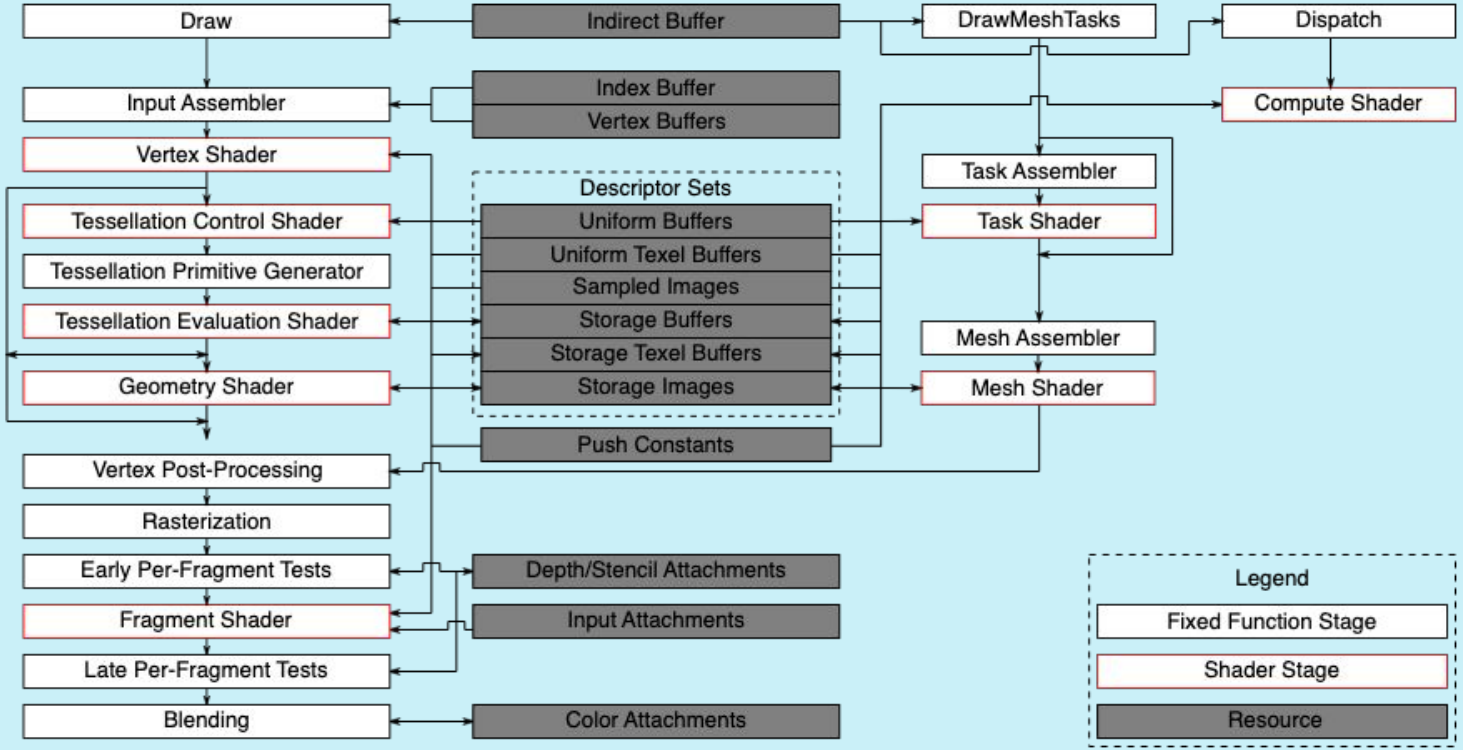
The Literal “Big Picture”



https://docs.vulkan.org/spec/latest/chapters/pipelines.html

Timeline

- What can be done in a semester? (Or about 15 weeks)
- A 4-credit hour undergrad course expects about 8-12 hours per week
- A graduate level course is closer to about 15-18 hours per week
- Set your expectations according to your workload!

Timeline

- Your progress make look different than others, which is fine!
- Some realistic semester-long goals are
  - Rendering an arbitrary 3D model imported from a file
  - Rendering a point-light
  - Handling basic user-input to modify your scene in some way

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Summary

- Learning Vulkan Independently often means learning lots of Non-Vulkan things, but it can be done!
- TONS of helpful resources to get started and make something cool
- The process of learning to use Vulkan will make you a better programmer and is very rewarding

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Misc Resources (General)

Fix Your Timestep! (Gaffer On Games)

shader-learning.com (Alexander Svyatoslavovich Alkevich)

realtimerendering.com (Ke-Sen Huang)

SIGGRAPH History (siggraph.org)

3D Math for Graphics (Fletcher Dunn)

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Misc Resources (Lighting)

Real Shading in Unreal Engine 4 (Brian Karis, Epic Games)

Reflection Models (Pat Hanrahan & Matt Pharr, Stanford University)

Irradiance Environment Maps (Ravi Ramamoorthi & Pat Hanrahan, Stanford)

Soft Shadows in Raymarched SDF (Inigo Quilez)

Physically Based Shading at Disney (Brent Burley, Walt Disney Animation Studios)

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Misc Resources (Animation)

Skinning (CS248, Stanford University)

Anim Coding (Adam Dutkiewicz)

ozz-animation (guillaumeblanc)

Skeletal Animation in GLTF (Nikita Lisitsa)

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Thank You!

https://github.com/clafollette303/

https://www.linkedin.com/in/clafollette303/