

# OpenGL<sup>®</sup>

## Programming Guide

*Ninth Edition*

*The Official Guide to Learning  
OpenGL<sup>®</sup>, Version 4.5 with SPIR-V*



John Kessenich • Graham Sellers • Dave Shreiner

The Khronos OpenGL ARB Working Group

# OpenGL Programming Guide

**Dan Ginsburg, Budirijanto  
Purnomo, Dave Shreiner, Aaftab Munshi**



## **OpenGL Programming Guide:**

*OpenGL Programming Guide* John Kessenich, Graham Sellers, Dave Shreiner, 2016-07-25 Complete Coverage of OpenGL 4.5 the Latest Version Includes 4.5.4 SPIR-V and Extensions The latest version of today's leading worldwide standard for computer graphics OpenGL 4.5 delivers significant improvements in application efficiency flexibility and performance OpenGL 4.5 is an exceptionally mature and robust platform for programming high quality computer generated images and interactive applications using 2D and 3D objects color images and shaders *OpenGL Programming Guide Ninth Edition* presents definitive comprehensive information on OpenGL 4.5.4 SPIR-V OpenGL extensions and the OpenGL Shading Language It will serve you for as long as you write or maintain OpenGL code This edition of the best selling Red Book fully integrates shader techniques alongside classic function centric approaches and contains extensive code examples that demonstrate modern techniques Starting with the fundamentals its wide ranging coverage includes drawing color pixels fragments transformations textures framebuffers light and shadow and memory techniques for advanced rendering and nongraphical applications It also offers discussions of all shader stages including thorough explorations of tessellation geometric and compute shaders New coverage in this edition includes Thorough coverage of OpenGL 4.5 Direct State Access DSA which overhauls the OpenGL programming model and how applications access objects Deeper discussions and more examples of shader functionality and GPU processing reflecting industry trends to move functionality onto graphics processors Demonstrations and examples of key features based on community feedback and suggestions Updated appendixes covering the latest OpenGL libraries related APIs functions variables formats and debugging and profiling techniques

*OpenGL Programming Guide*, 2007      *OpenGL Programming Guide* Dave Shreiner, Graham Sellers, John Kessenich, Bill Licea-Kane, 2013-03-19 Includes Complete Coverage of the OpenGL Shading Language Today's OpenGL software interface enables programmers to produce extraordinarily high quality computer generated images and interactive applications using 2D and 3D objects color images and programmable shaders *OpenGL Programming Guide The Official Guide to Learning OpenGL Version 4.3 Eighth Edition* has been almost completely rewritten and provides definitive comprehensive information on OpenGL and the OpenGL Shading Language This edition of the best selling Red Book describes the features through OpenGL version 4.3 It also includes updated information and techniques formerly covered in *OpenGL Shading Language the Orange Book* For the first time this guide completely integrates shader techniques alongside classic functioncentric techniques Extensive new text and code are presented demonstrating the latest in OpenGL programming techniques *OpenGL Programming Guide Eighth Edition* provides clear explanations of OpenGL functionality and techniques including processing geometric objects with vertex tessellation and geometry shaders using geometric transformations and viewing matrices working with pixels and texture maps through fragment shaders and advanced data techniques using framebuffer objects and compute shaders New OpenGL features covered in this edition include Best practices and sample code for taking full

advantage of shaders and the entire shading pipeline including geometry and tessellation shaders Integration of general computation into the rendering pipeline via compute shaders Techniques for binding multiple shader programs at once during application execution Latest GLSL features for doing advanced shading techniques Additional new techniques for optimizing graphics program performance

**OpenGL Programming Guide : the Official Guide to Learning OpenGL, Version 4.3**, 2013 *OpenGL Programming Guide* Jackie Neider, Tom Davis, Mason Woo, OpenGL Architecture Review Board, 1993 This book explains how to create graphics programs using OpenGL Release 1 It presents the overall architecture of OpenGL and discusses in detail every function included in the specification Numerous programming examples in C show how to use OpenGL functions

*OpenGL ES 2.0 Programming Guide* Aaftab Munshi, Dan Ginsburg, Dave Shreiner, 2008-07-24 OpenGL ES 2.0 is the industry's leading software interface and graphics library for rendering sophisticated 3D graphics on handheld and embedded devices With OpenGL ES 2.0 the full programmability of shaders is now available on small and portable devices including cell phones PDAs consoles appliances and vehicles However OpenGL ES differs significantly from OpenGL Graphics programmers and mobile developers have had very little information about it until now In the OpenGL ES 2.0 Programming Guide three leading authorities on the OpenGL ES 2.0 interface including the specification's editor provide start to finish guidance for maximizing the interface's value in a wide range of high performance applications The authors cover the entire API including Khronos ratified extensions Using detailed C based code examples they demonstrate how to set up and program every aspect of the graphics pipeline You'll move from introductory techniques all the way to advanced per pixel lighting particle systems and performance optimization Coverage includes Shaders in depth creating shader objects compiling shaders checking for compile errors attaching shader objects to program objects and linking final program objects The OpenGL ES Shading Language variables types constructors structures arrays attributes uniforms varying precision qualifiers and invariance Inputting geometry into the graphics pipeline and assembling geometry into primitives Vertex shaders their special variables and their use in per vertex lighting skinning and other applications Using fragment shaders including examples of multitexturing fog alpha test and user clip planes Fragment operations scissor test stencil test depth test multisampling blending and dithering Advanced rendering per pixel lighting with normal maps environment mapping particle systems image post processing and projective texturing Real world programming challenges platform diversity C portability OpenKODE and platform specific shader binaries

**OpenGL Programming Guide** Dave Shreiner, OpenGL Architecture Review Board, 2008 OpenGL Programming Guide Sixth Edition OpenGL is a powerful software interface used to produce high quality computer generated images and interactive applications using 2D and 3D objects bitmaps and color images The OpenGL Programming Guide Sixth Edition provides definitive and comprehensive information on OpenGL and the OpenGL Utility Library The previous edition covered OpenGL through Version 2.0 This sixth edition of the best selling red book describes the latest features of OpenGL Version 2.1 You

will find clear explanations of OpenGL functionality and many basic computer graphics techniques such as building and rendering 3D models interactively viewing objects from different perspective points and using shading lighting and texturing effects for greater realism In addition this book provides in depth coverage of advanced techniques including texture mapping antialiasing fog and atmospheric effects NURBS image processing and more The text also explores other key topics such as enhancing performance OpenGL extensions and cross platform techniques This sixth edition has been updated to include the newest features of OpenGL Version 2.1 including Using server side pixel buffer objects for fast pixel rectangle download and retrieval Discussion of the sRGB texture format Expanded discussion of the OpenGL Shading Language This edition continues the discussion of the OpenGL Shading Language GLSL and explains the mechanics of using this language to create complex graphics effects and boost the computational power of OpenGL The OpenGL Technical Library provides tutorial and reference books for OpenGL The Library enables programmers to gain a practical understanding of OpenGL and shows them how to unlock its full potential Originally developed by SGI the Library continues to evolve under the auspices of the OpenGL Architecture Review Board ARB Steering Group now part of the Khronos Group an industry consortium responsible for guiding the evolution of OpenGL and related technologies

**OpenGL Programming Guide** Dave Shreiner, 2010 OpenGL is a powerful software interface used to produce high quality computer generated images and interactive applications using 2D and 3D objects bitmaps and color images The OpenGL Programming Guide Seventh Edition provides definitive and comprehensive information on OpenGL and the OpenGL Utility Library The previous edition covered OpenGL through Version 2.1 This seventh edition of the best selling red book describes the latest features of OpenGL Versions 3.0 and 3.1 You will find clear explanations of OpenGL functionality and many basic computer graphics techniques such as building and rendering 3D models interactively viewing objects from different perspective points and using shading lighting and texturing effects for greater realism In addition this book provides in depth coverage of advanced techniques including texture mapping antialiasing fog and atmospheric effects NURBS image processing and more The text also explores other key topics such as enhancing performance OpenGL extensions and cross platform techniques This seventh edition has been updated to include the newest features of OpenGL Versions 3.0 and 3.1 including Using framebuffer objects for off screen rendering and texture updates Examples of the various new buffer object types including uniform buffer objects transform feedback buffers and vertex array objects Using texture arrays to increase performance when using numerous textures Efficient rendering using primitive restart and conditional rendering Discussion of OpenGL's deprecation mechanism and how to verify your programs for future versions of OpenGL This edition continues the discussion of the OpenGL Shading Language GLSL and explains the mechanics of using this language to create complex graphics effects and boost the computational power of OpenGL The OpenGL Technical Library provides tutorial and reference books for OpenGL The Library enables programmers to gain a practical understanding of OpenGL and shows them how to unlock its full

potential Originally developed by SGI the Library continues to evolve under the auspices of the Khronos OpenGL ARB Working Group an industry consortium responsible for guiding the evolution of OpenGL and related technologies

**OpenGL Programming Guide** Dave Shreiner,OpenGL Architecture Review Board,2006 OpenGL runs on any platform has many supporting tools and applications and is used to create powerful graphic applications This new edition will provide basic information about GLSL itself as well as all the other changes to the 1 5 and 1 0 versions OpenGL Programming Guide Dave Shreiner,OpenGL Architecture Review Board,2004 Fully updated for OpenGL Versions 1 3 and 1 4 with many new example programs and colour slides bull Introduces the new shading technologies including the ARB vertex and fragment program extension bull Written under the auspices of the OpenGL Architectural Review Board the previous edition alone has sold more than 40 000 copies *OpenGL Programming Guide* ,1999 **OpenGL Programming Guide** Dave Shreiner,Randi J. Rost,OpenGL Architecture Review Board,OpenGL Architecture Review Board Staff,2006 **OpenGL Programming Guide** Dave Shreiner,The Khronos OpenGL ARB Working,2009-07-21 Please note that this title s color insert referred to as Plates within the text is not available for this digital product OpenGL is a powerful software interface used to produce high quality computer generated images and interactive applications using 2D and 3D objects bitmaps and color images The OpenGL Programming Guide Seventh Edition provides definitive and comprehensive information on OpenGL and the OpenGL Utility Library The previous edition covered OpenGL through Version 2 1 This seventh edition of the best selling red book describes the latest features of OpenGL Versions 3 0 and 3 1 You will find clear explanations of OpenGL functionality and many basic computer graphics techniques such as building and rendering 3D models interactively viewing objects from different perspective points and using shading lighting and texturing effects for greater realism In addition this book provides in depth coverage of advanced techniques including texture mapping antialiasing fog and atmospheric effects NURBS image processing and more The text also explores other key topics such as enhancing performance OpenGL extensions and cross platform techniques This seventh edition has been updated to include the newest features of OpenGL Versions 3 0 and 3 1 including Using framebuffer objects for off screen rendering and texture updates Examples of the various new buffer object types including uniform buffer objects transform feedback buffers and vertex array objects Using texture arrays to increase performance when using numerous textures Efficient rendering using primitive restart and conditional rendering Discussion of OpenGL s deprecation mechanism and how to verify your programs for future versions of OpenGL This edition continues the discussion of the OpenGL Shading Language GLSL and explains the mechanics of using this language to create complex graphics effects and boost the computational power of OpenGL The OpenGL Technical Library provides tutorial and reference books for OpenGL The Library enables programmers to gain a practical understanding of OpenGL and shows them how to unlock its full potential Originally developed by SGI the Library continues to evolve under the auspices of the Khronos OpenGL ARB Working Group an industry consortium responsible for guiding the

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*Programming Guide* Dan Ginsburg,Budirijanto Purnomo,Dave Shreiner,Aaftab Munshi,2014-02-28 OpenGL ES TM is the  
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authors cover the entire API and Shading Language They carefully introduce OpenGL ES 3 0 features such as shadow  
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feedback Through detailed downloadable C based code examples you ll learn how to set up and program every aspect of the  
graphics pipeline Step by step you ll move from introductory techniques all the way to advanced per pixel lighting and  
particle systems Throughout you ll find cutting edge tips for optimizing performance maximizing efficiency with both the API  
and hardware and fully leveraging OpenGL ES 3 0 in a wide spectrum of applications All code has been built and tested on  
iOS 7 Android 4 3 Windows OpenGL ES 3 0 Emulation and Ubuntu Linux and the authors demonstrate how to build OpenGL  
ES code for each platform Coverage includes EGL API communicating with the native windowing system choosing  
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shaders checking for compile errors creating linking and querying program objects and using source shaders and program  
binaries OpenGL ES Shading Language variables types constructors structures arrays attributes uniform blocks I O variables  
precision qualifiers and invariance Geometry vertices and primitives inputting geometry into the pipeline and assembling it  
into primitives 2D 3D Cubemap Array texturing creation loading and rendering texture wrap modes filtering and formats  
compressed textures sampler objects immutable textures pixel unpack buffer objects and mipmapping Fragment shaders  
multitexturing fog alpha test and user clip planes Fragment operations scissor stencil and depth tests multisampling blending  
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environment mapping particle systems image post processing procedural textures shadow mapping terrain and projective  
texturing Sync objects and fences synchronizing within host application and GPU execution This edition of the book includes  
a color insert of the OpenGL ES 3 0 API and OpenGL ES Shading Language 3 0 Reference Cards created by Khronos The  
reference cards contain a complete list of all of the functions in OpenGL ES 3 0 along with all of the types operators  
qualifiers built ins and functions in the OpenGL ES Shading Language      **OpenGL Programming Guide** Mason Woo,Jackie  
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includes 16 pages of full color examples      OpenGL Superbible Richard S. Wright, Michael Sweet, 1996 Until OpenGL SuperBible there has been scant material explaining how to use OpenGL under Windows This thorough resource shows developers the basics of OpenGL programming describes how OpenGL works with Windows and provides a comprehensive reference to all OpenGL functions and commands      **OpenGL® ES 2.0 Programming Guide** Aaftab Munshi, Dave Shreiner, Dan Ginsburg, 2008 OpenGL ES 2.0 is the industry's leading software interface and graphics library for rendering sophisticated 3D graphics on handheld and embedded devices With OpenGL ES 2.0 the full programmability of shaders is now available on small and portable devices including cell phones PDAs consoles appliances and vehicles However OpenGL ES differs significantly from OpenGL Graphics programmers and mobile developers have had very little information about it until now In the OpenGL ES 2.0 Programming Guide three leading authorities on the OpenGL ES 2.0 interface including the specification's editor provide start to finish guidance for maximizing the interface's value in a wide range of high performance applications The authors cover the entire API including Khronos ratified extensions Using detailed C based code examples they demonstrate how to set up and program every aspect of the graphics pipeline You'll move from introductory techniques all the way to advanced per pixel lighting particle systems and performance optimization Coverage includes Shaders in depth creating shader objects compiling shaders checking for compile errors attaching shader objects to program objects and linking final program objects The OpenGL ES Shading Language variables types constructors structures arrays attributes uniforms varying precision qualifiers and invariance Inputting geometry into the graphics pipeline and assembling geometry into primitives Vertex shaders their special variables and their use in per vertex lighting skinning and other applications Using fragment shaders including examples of multitexturing fog alpha test and user clip planes Fragment operations scissor test stencil test depth test multisampling blending and dithering Advanced rendering per pixel lighting with normal maps environment mapping particle systems image post processing and projective texturing Real world programming challenges platform diversity C portability OpenKODE and platform specific shader binaries

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