penGL ES

CSCI 4239/5239
Advanced Computer Graphics
Spring 2021

OpenGL ES

- OpenGL for Embedded Systems
  - Phones
  - Game consoles
  - Appliances
  - Avionics
  - Subsystems (e.g. browsers)
  - ...
- Cross-platform, open, standard

What is it?

- OpenGL adapted for Embedded Systems
  - Less capable hardware
    - Limited memory
    - Limited processing power
    - Lower clock frequencies
  - Lower power consumption
    - Less heat dissipation
- Same familiar API
  - Subset of full OpenGL API
  - Powerful 3D graphics in your pocket

OpenGL ES Advantages

- Standard and Royalty Free
- Small footprint
- Low power consumption
- Seamless hardware acceleration
- Extensible and evolving
- Easy to use
- Well documented

Current Applications

- Mobile devices
  - iPhone/iPod/iPad
  - Android
- WebGL
  - Chrome, Firefox, Safari, Opera, ...
- Embeded systems
  - 3D displays

OpenGL ES 1.1

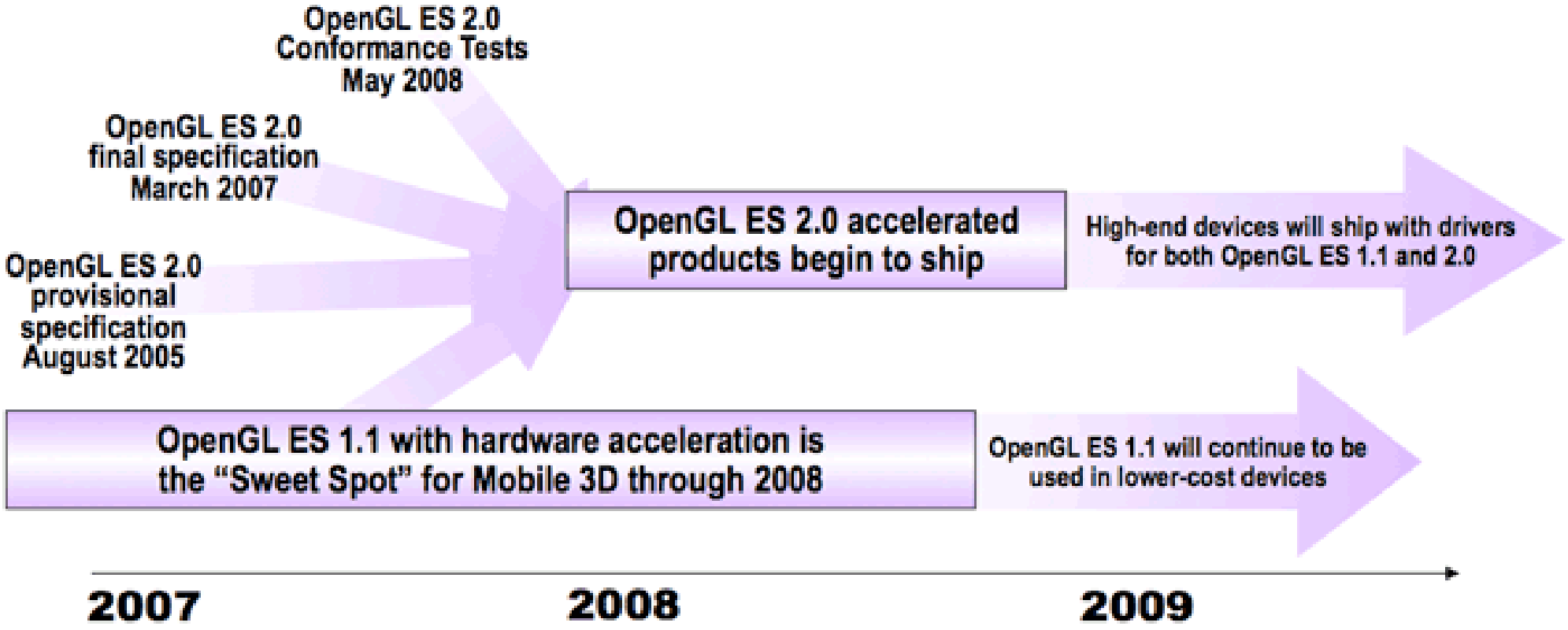
- Feature upgrade from OpenGL ES 1.0
- Defined relative to OpenGL 1.5
- Fixed pipeline (no shaders)
- Removes some functionality
  - No glBegin() … glEnd()
    - Replaced with glDrawArrays() & glDrawElements()
  - No GL_QUAD or GL_POLYGON
  - No display lists
- Still provides lighting, textures, etc.

OpenGL ES 2.0 and later

- **Not backwards compatible with ES 1.1**
- Defined relative to OpenGL 2.0
- Shaders only (no fixed pipeline)
  - No lighting except in shaders
  - Textures only in shaders
- Removes transformation functions
  - No glRotate() glScale() glTranslate()
- OpenGL ES 3.0 adds feature upgrades

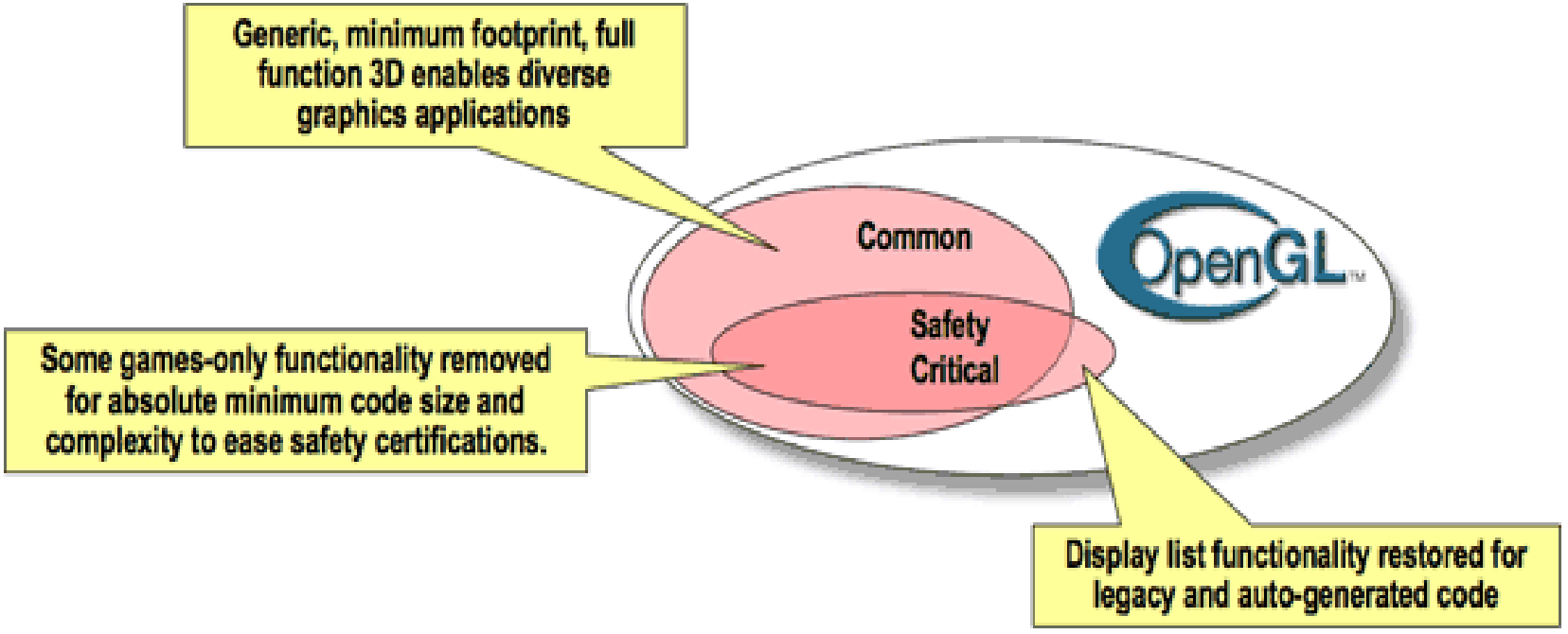
OpenGL ES Evolution

- **OpenGL ES 2.0 silicon implementations now shipping**
  - Shader-based graphics comes to mobile
  - Conformance tests shipping in May 2008
- **Listening carefully to implementation and developer feedback**
  - The determine next-generation requirements



OpenGL SC

- OpenGL for Safety Critical applications
  - Avionics
  - Automotive
  - Industrial
  - Medical
  - Military



OpenGL SC Features

- SC 1.0 starts with OpenGL ES 1.0
  - Adds back some features
    - Begin/End
    - Display Lists
    - Some raster ops
    - Anti-aliasing
  - Removes some features
    - Fog
- SC 2.0 starts with OpenGL ES 2.0

WebGL

- OpenGL ES 2.0 for the web
- Extends Javascript
- Operates on HTML5 canvas element
- Prohibits client side arrays
  - All vertex, normal, color, … must be stored in Vertex Buffer Object on video card
- Becoming more mainstream
  - Still a work in progress

WebGL Platforms

- Supported by most browsers
  - Chromium
  - Firefox
  - Safari
  - Opera
  - Explorer/Edge/...
- Update to recent version
  - Local file access workarounds

Apple iOS Devices

- Supports OpenGL ES 1.1 and 2.0
- User interface is Objective C
  - Links to C and C++ code
- Develop with Xcode on Mac only
- Emulator for all devices
  - Slower than native devices
  - Almost perfect emulation
- Apple is replacing OpenGL with Metal

Getting iOS Tools

- Download Xcode from Apple
  - many GB download
- Provides compiler, frameworks, etc
- Create project in Xcode
- Select target iPhone/iPad
- Emulator launched on run
- Get command line tools also

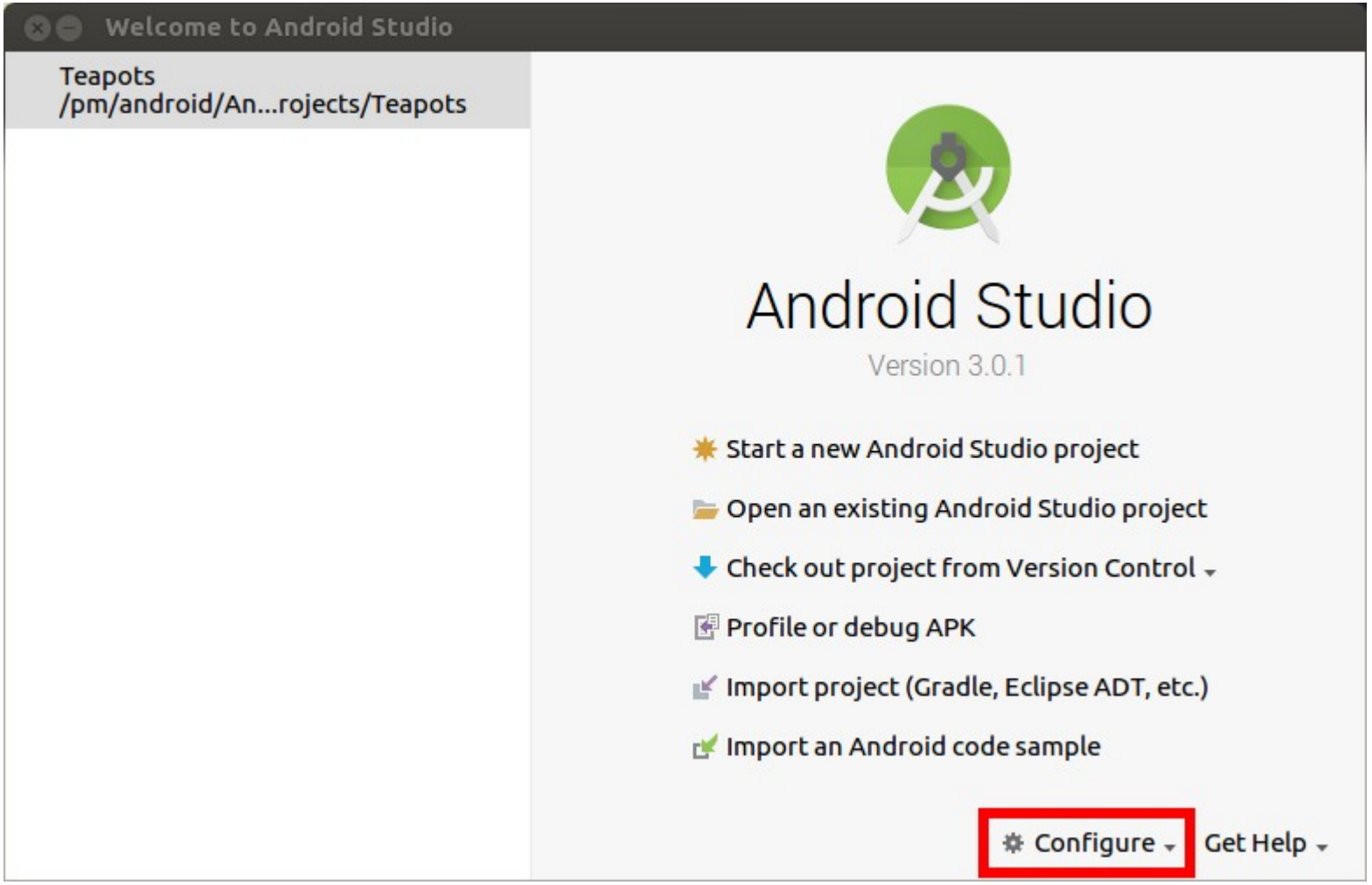
Android Devices

- Supports OpenGL ES 1.1 or 2.0
  - Higher end devices support 1.1 AND 2.0
  - Low end devices may only do 1.1
- User interface is Java
  - Link to C/C++ code with JNI
- Develop with NDK
- Emulator for phones and tablets
  - Slower than native devices
  - Hardware acceleration much improved

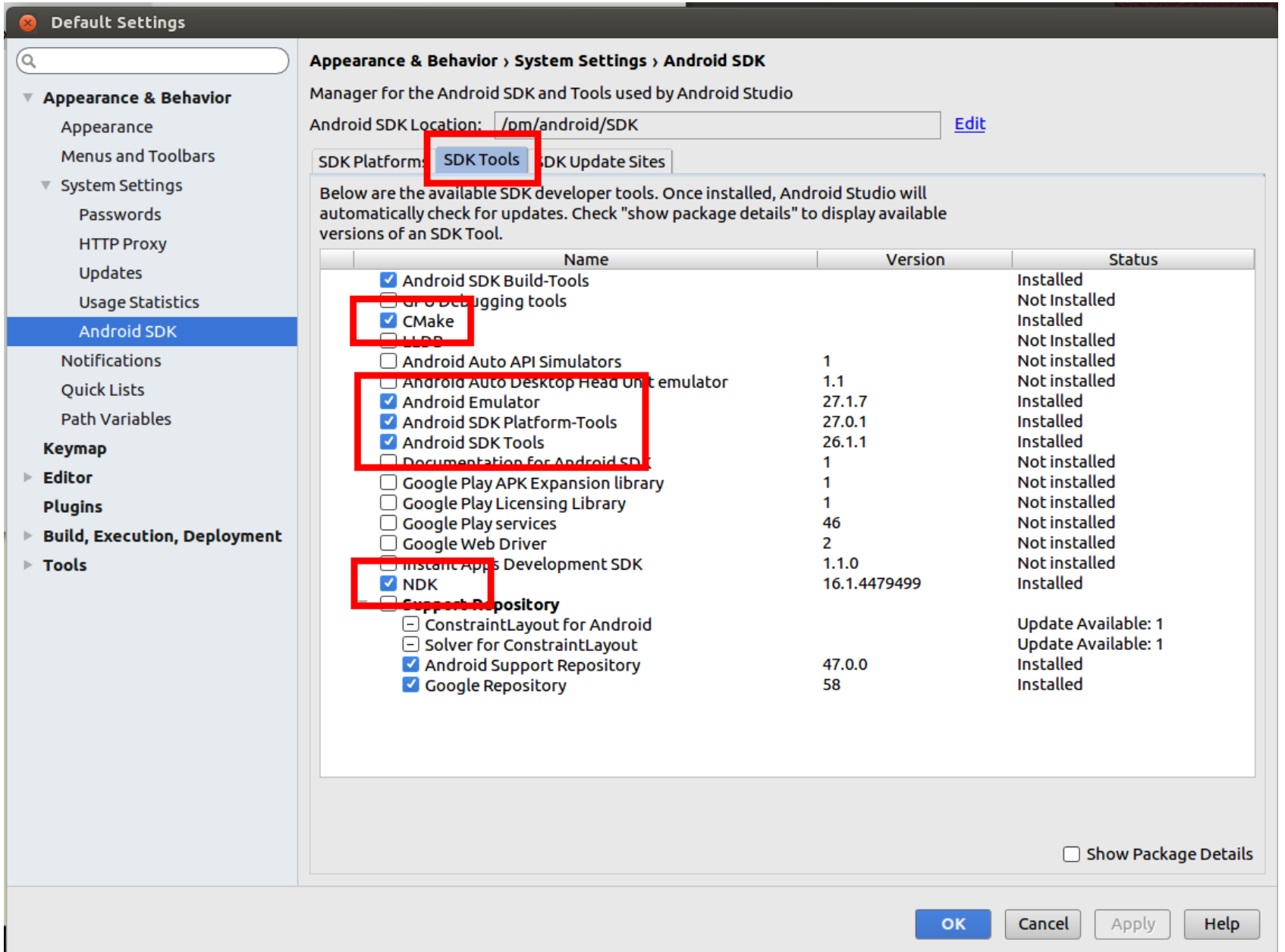
Android Tools

- Download Android Studio
  - https://developer.android.com/studio/
  - About 750MB ZIP file
- Unzip and find studio.sh or studio.exe
- Use Configure to download SDK, NDK
- Add Android tools to PATH
  - ..../SDK/tools
  - ..../SDK/platform-tools
  - ..../SDK/ndk-bundle
- Create AVDs

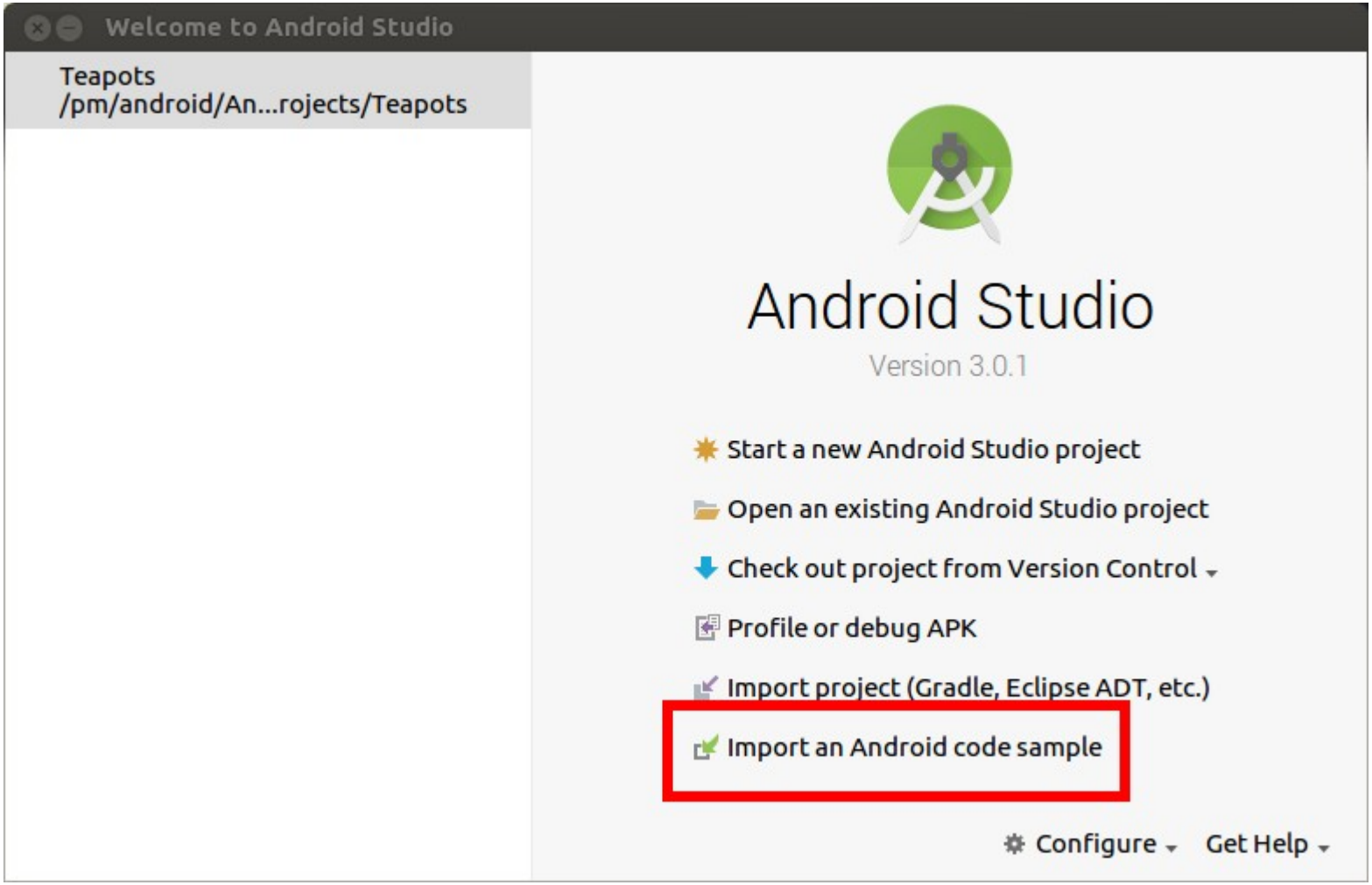
Initial SDK Configuration



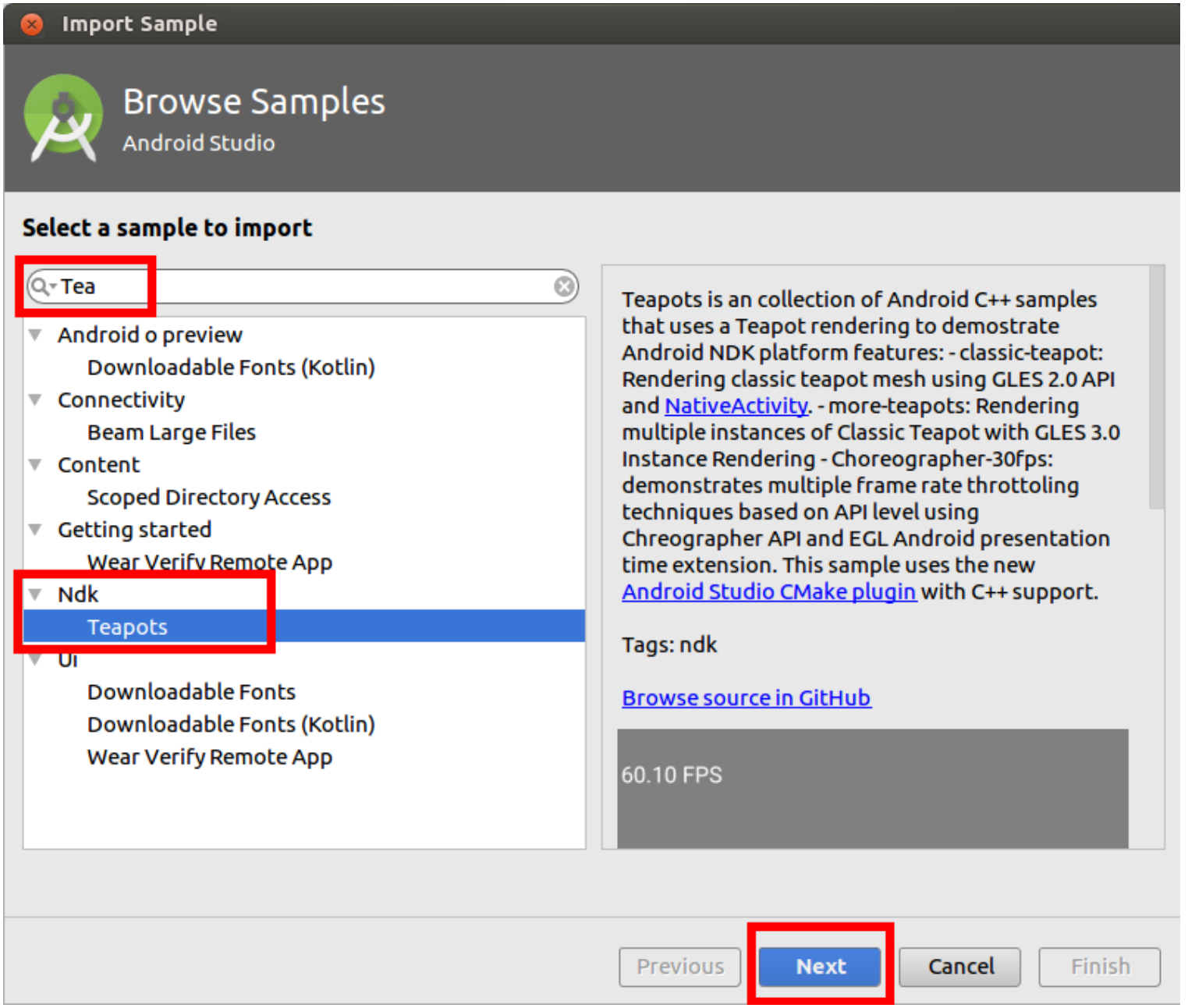
Select and install SDK Tools



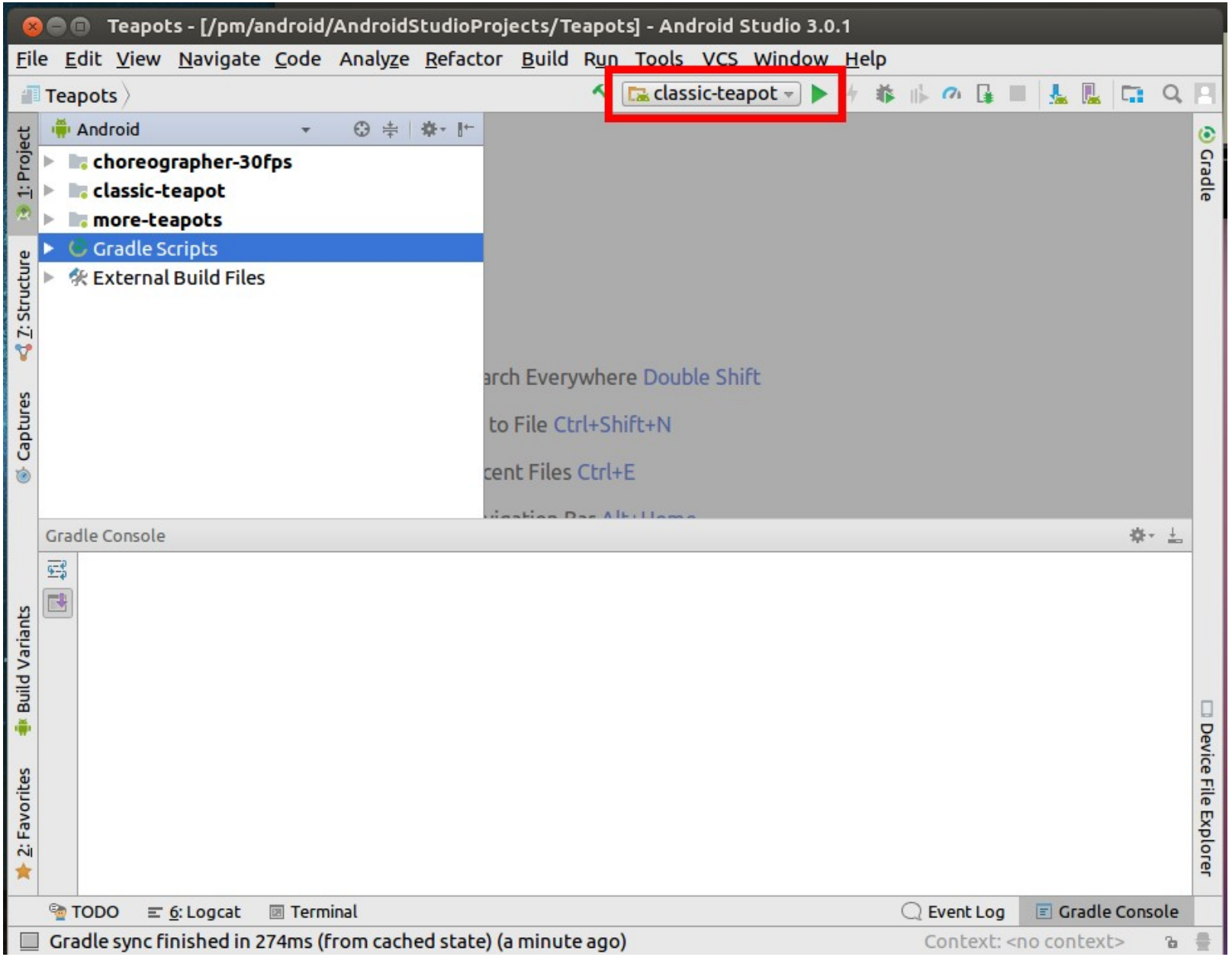
Import Code Example



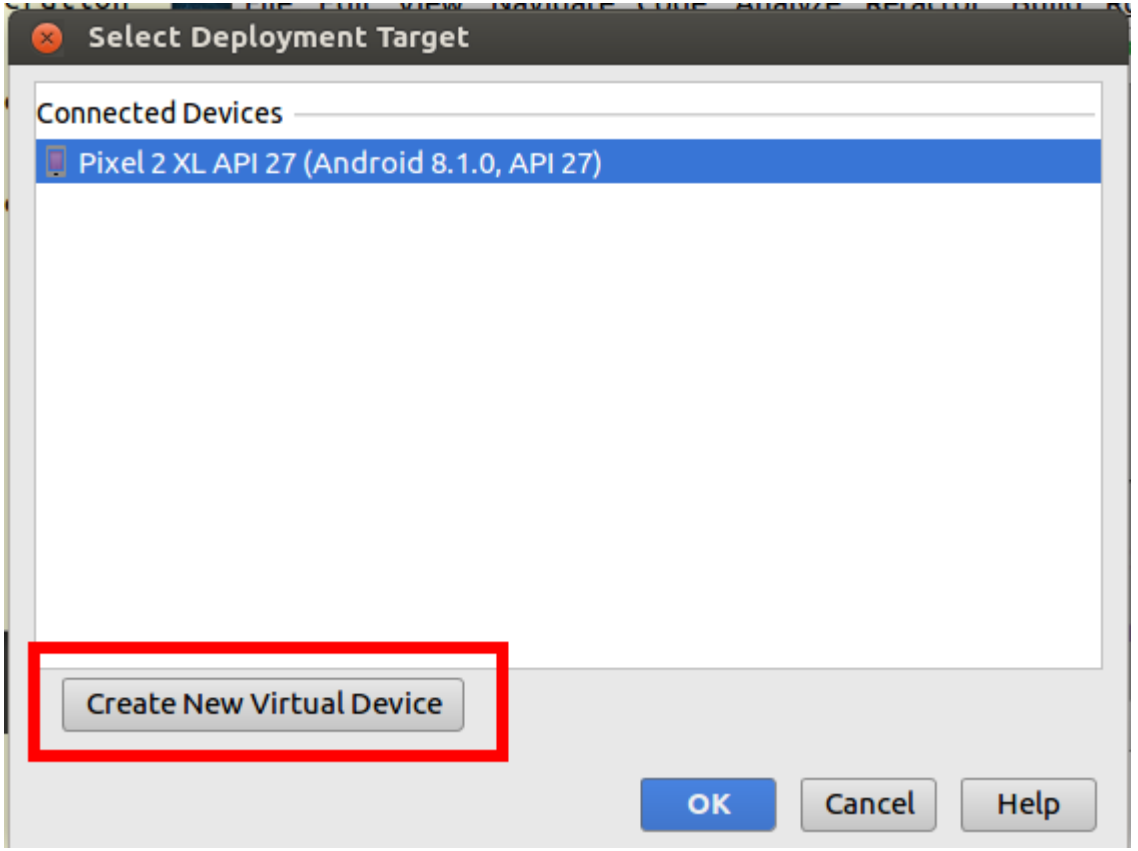
Teapots NDK/OpenGL ES 2.0



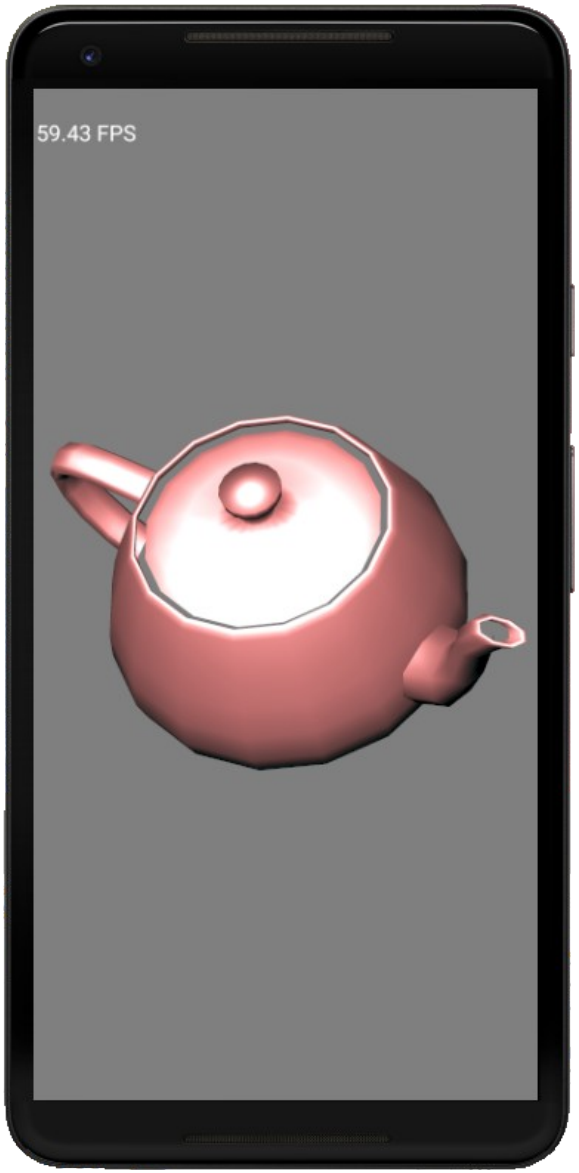
Select Target, Build and Run

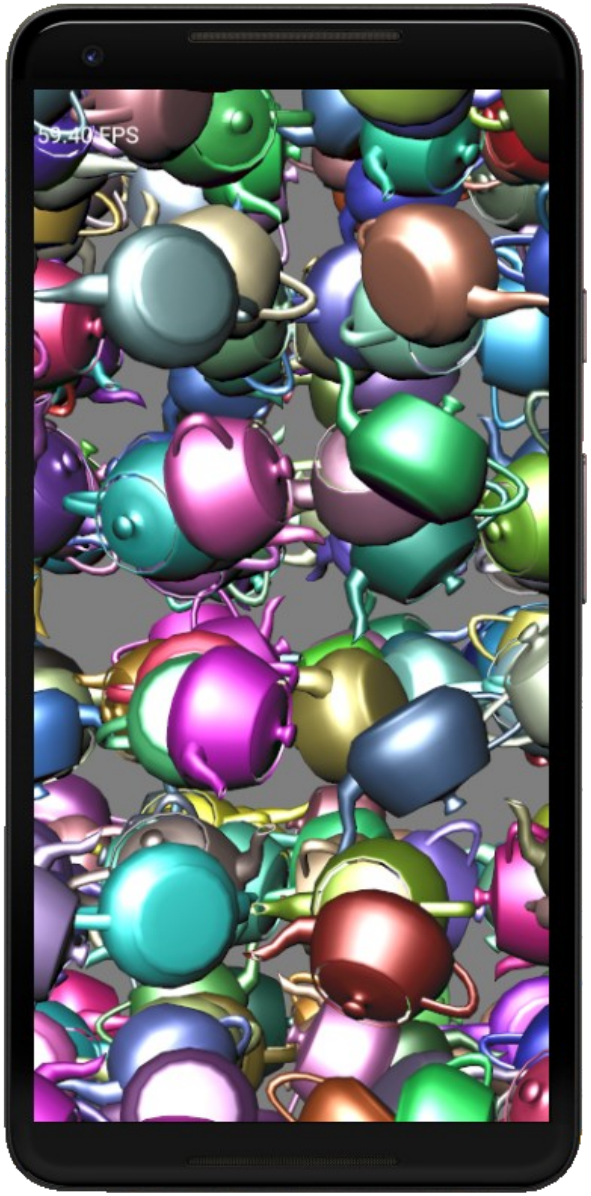


Create Virtual Device using Wizard



teapot, textured-teapot and more-teapots





Portable OpenGL ES Code

- Write the bulk of the code in C++
  - OpenGL ES 1.1 will run on all devices
  - OpenGL ES 2.0 will run on higer end devices
- Write minimal code in interface language
  - Objective C – link to C/C++
  - Java – call C/C++ using JNI
- Qt 5 for iOS/Qt 5 for Android
  - Later builds are better

Assignment 5

- Create a scene that can be viewed in 3D using WebGL or IOS or Android
  - Must support lighting and textures
  - Objects must be created in code
    - I want you to get some experience using vertex buffer objects
    - WebGL may use mat4.js or CanvasMatrix library, but NOT Three.js or similar high level libraries
- Explore features like buttons