OpenGL ES

CSCI 4239/5239
Advanced Computer Graphics
Spring 2023

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, ...
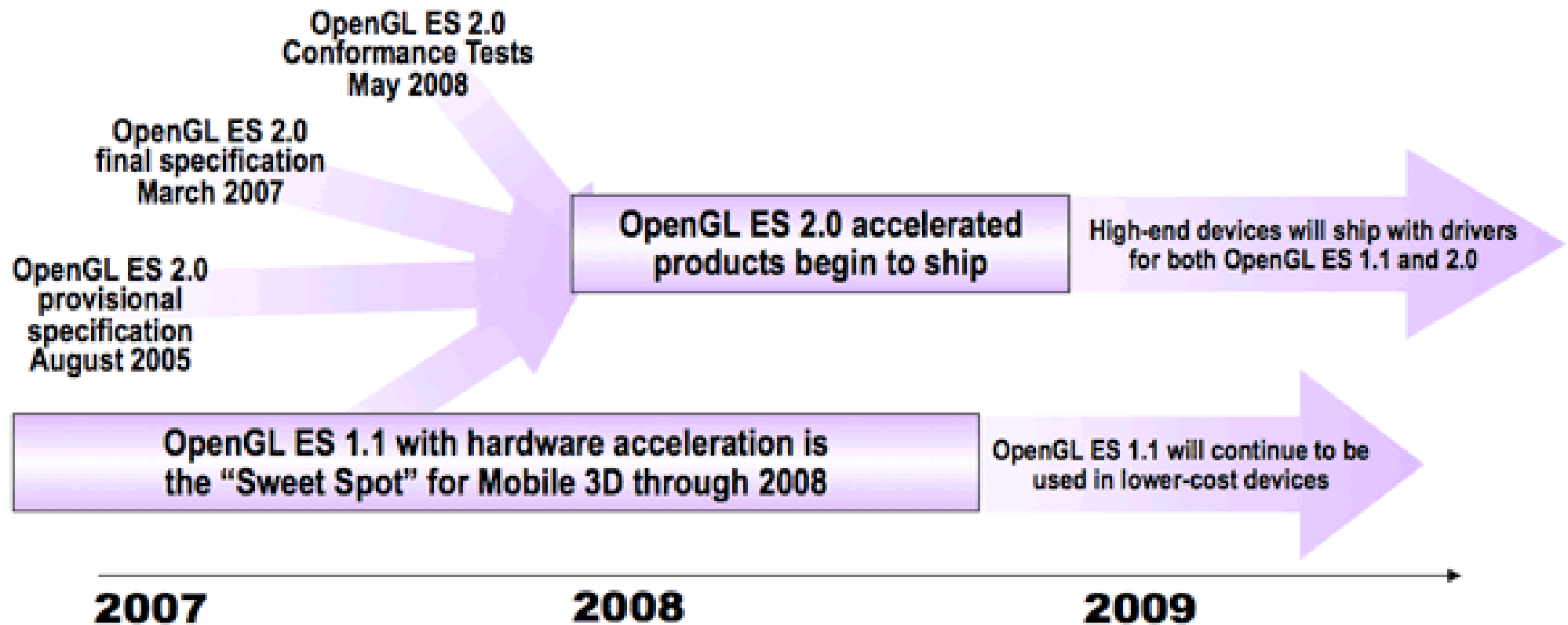- Embeded systems
  - 3D displays

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
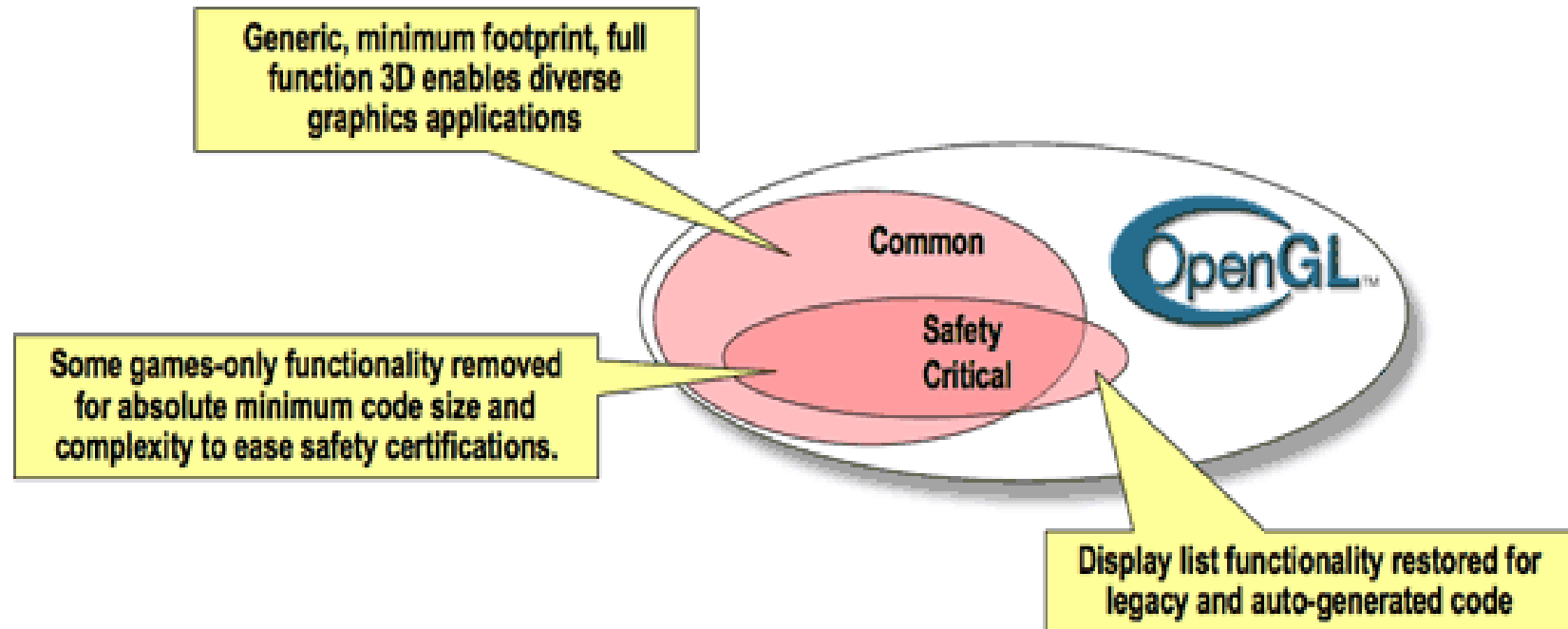 - The determine next-generation requirements

OpenGL ES 2.0
Conformance Tests
May 2008

OpenGL ES 2.0
final specification
March 2007

OpenGL ES 2.0
provisional
specification
August 2005

OpenGL ES 2.0 accelerated products begin to ship

High-end devices will ship with drivers for both OpenGL ES 1.1 and 2.0

OpenGL ES 1.1 with hardware acceleration is the "Sweet Spot" for Mobile 3D through 2008

OpenGL ES 1.1 will continue to be used in lower-cost devices

2007   **2008**   **2009**

OpenGL SC

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

Generic, minimum footprint, full function 3D enables diverse graphics applications

Some games-only functionality removed for absolute minimum code size and complexity to ease safety certifications.

Common

Safety Critical

Display list functionality restored for legacy and auto-generated code

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
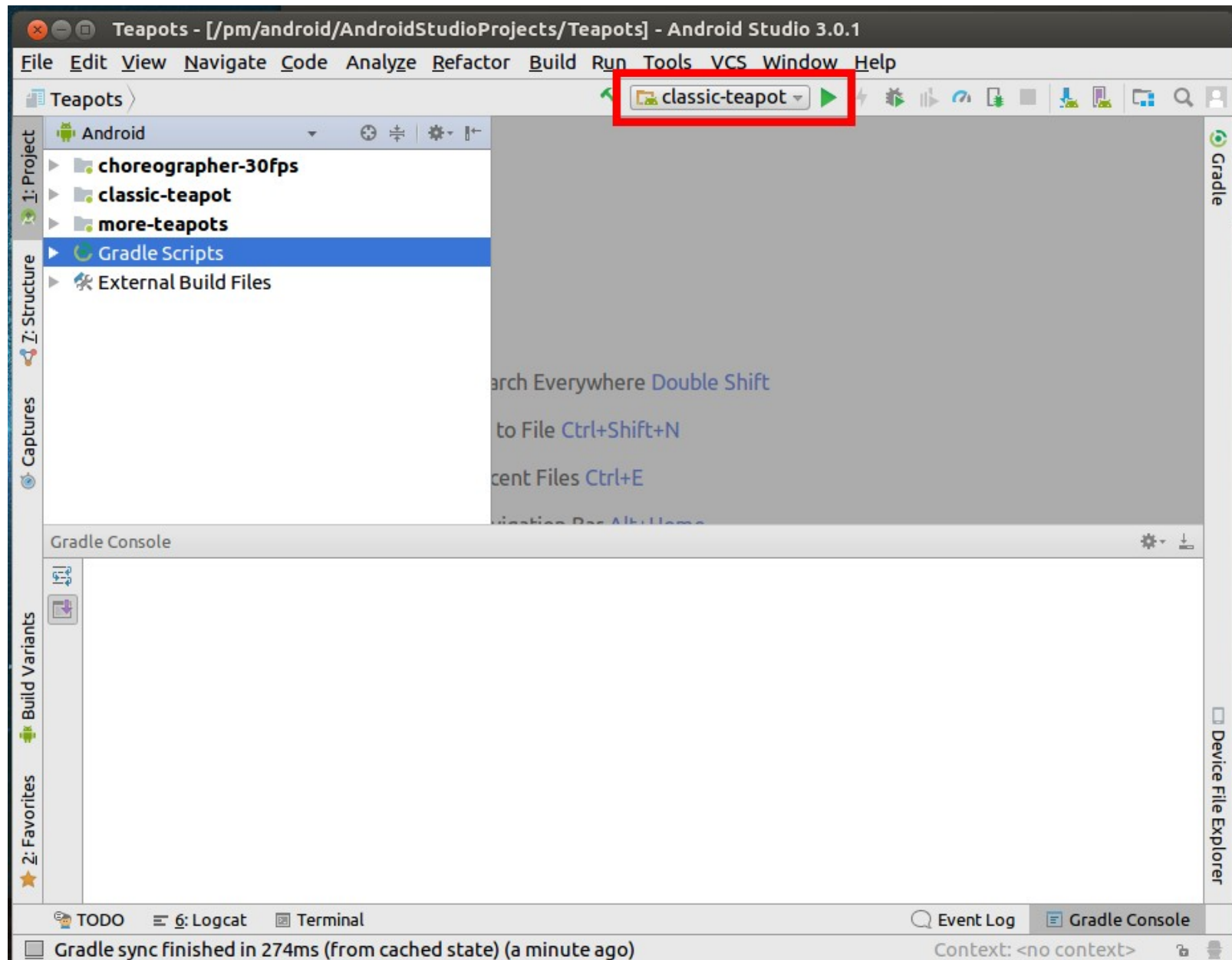- Create AVDs

Initial SDK Configuration
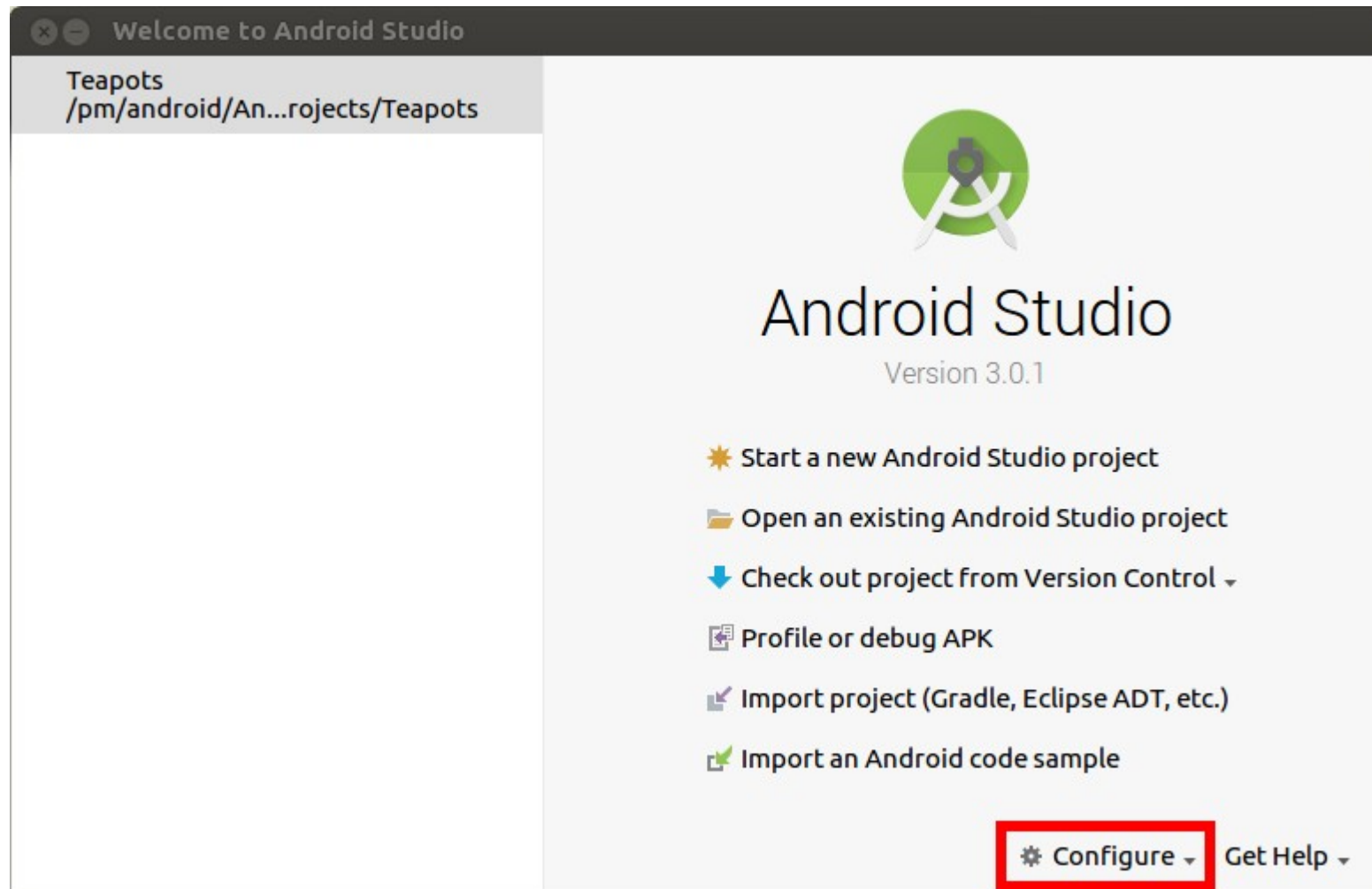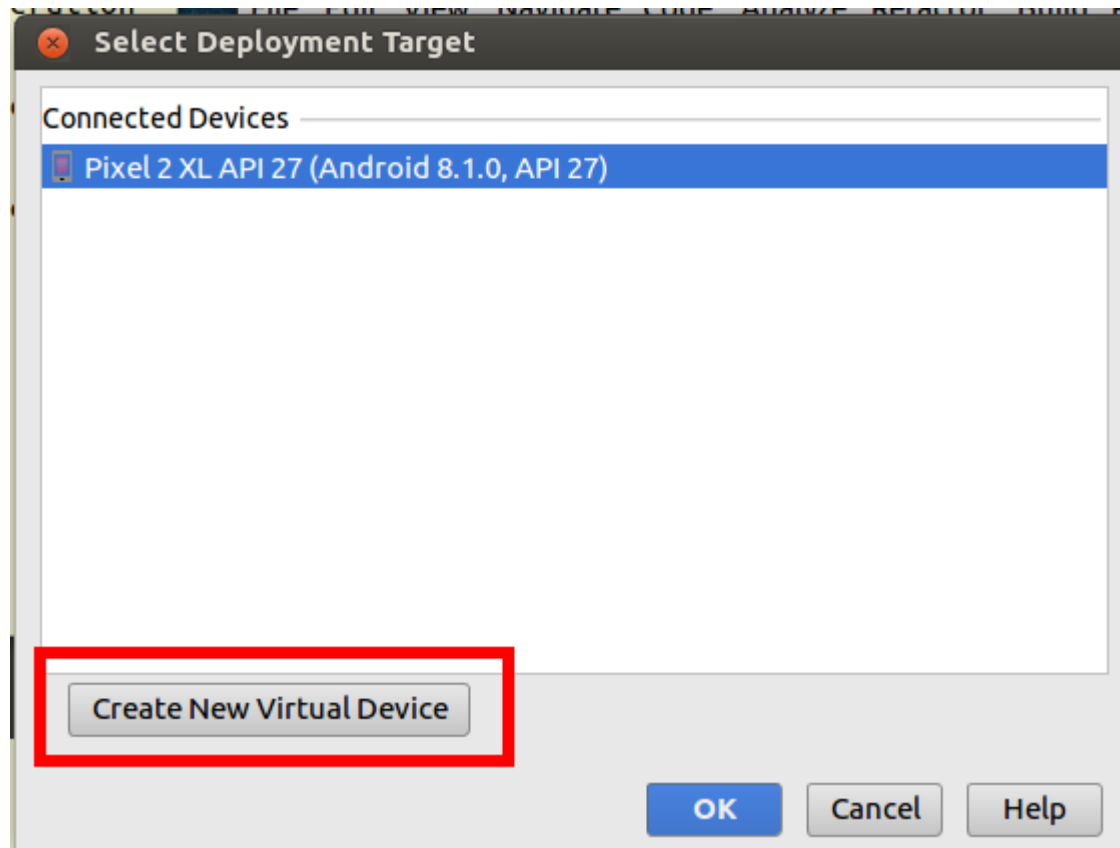
Select and install SDK Tools

Import Code Example

Teapots NDK/OpenGL ES 2.0
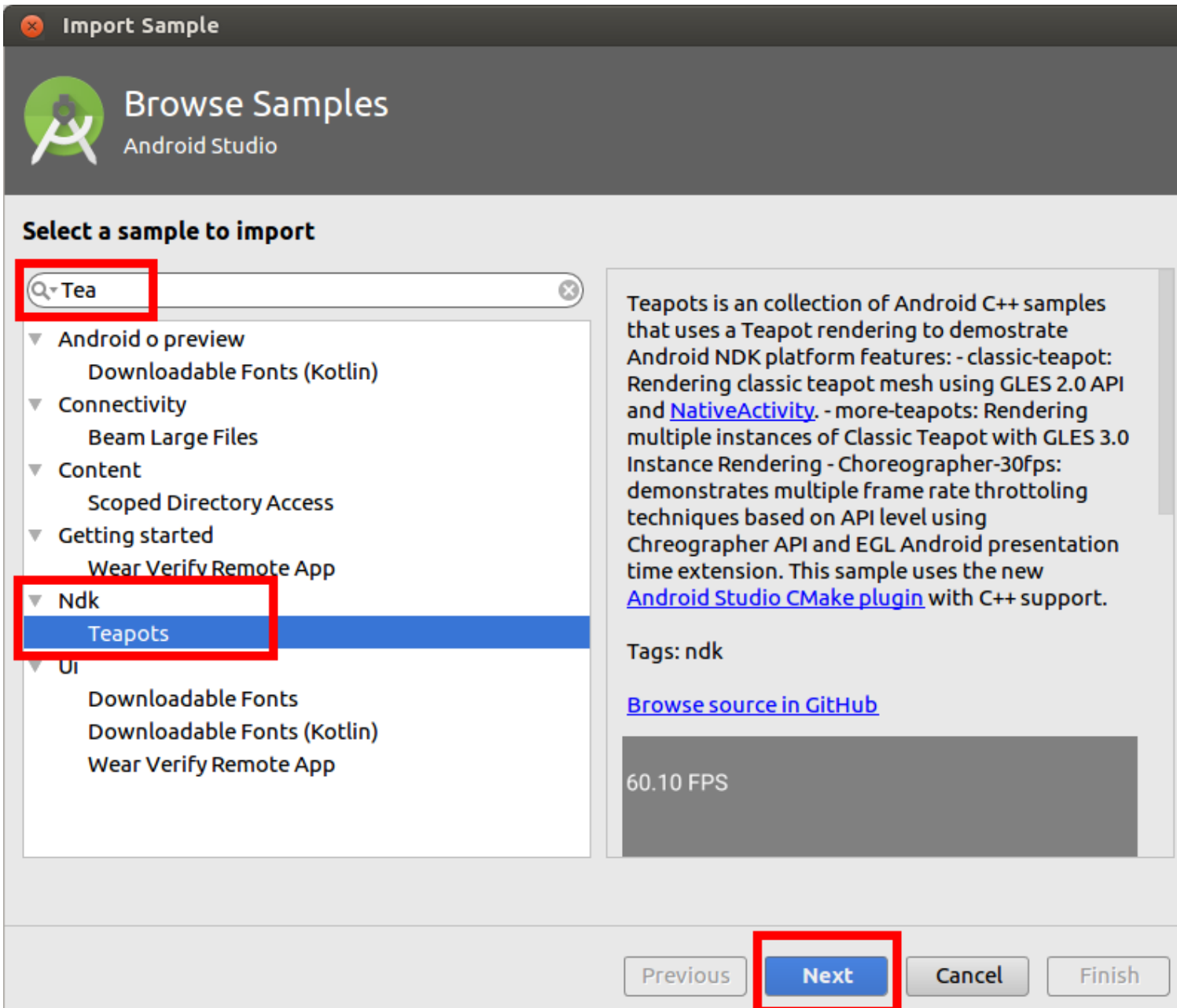
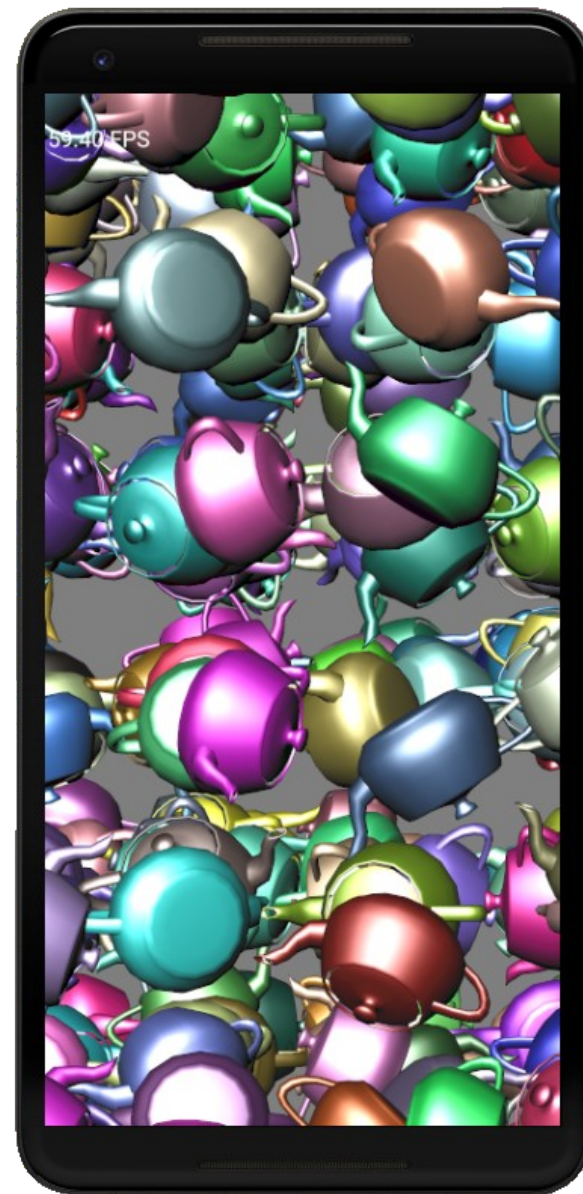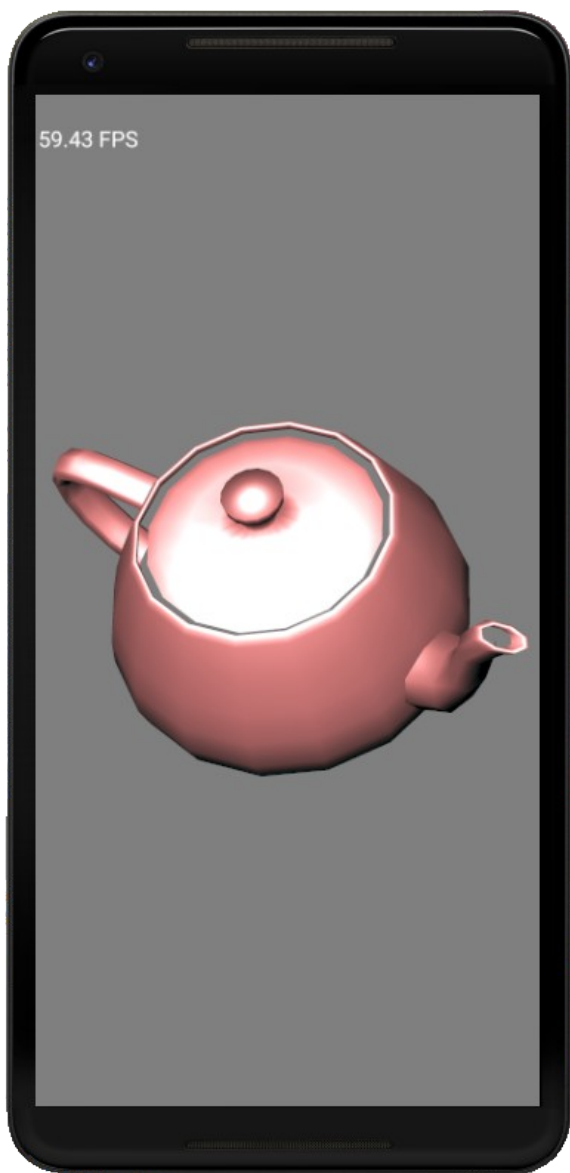# Select Target, Build and Run

Create Virtual Device using Wizard

teapot, textured-teapot and more-teapots

59.43 FPS

59.61 FPS

59.40 FPS

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