

# **CMSC436: Programming Handheld Systems**

# **Android Development Environment**

# The Android Platform

A multi-layered software stack for building and running mobile applications

# The Android Development Environment

Your workbench for writing Android applications

See:

<https://developer.android.com/studio/intro/>

# Today's Topics

Downloading Android SDK

Using the Android Studio IDE

Using the Android emulator

Debugging Android applications

Other tools

# Prerequisites

## Supported Operating Systems:

Microsoft Windows 7/8/10 (32- or 64-bit)

Mac OS X 10.10 (Yosemite) up to 10.12 (Sierra)

GNOME or KDE desktop (tested on Ubuntu 14.04 LTS, Trusty Tahr)

# Prerequisites

3 GB RAM min, 4 GB RAM rec

1 GB+ for Android SDK, emulator system images,  
and caches

1280 x 800 min screen resolution

# Getting Started

Download & install Android Studio

See: <https://developer.android.com/studio/index.html#downloads>

# Android Studio

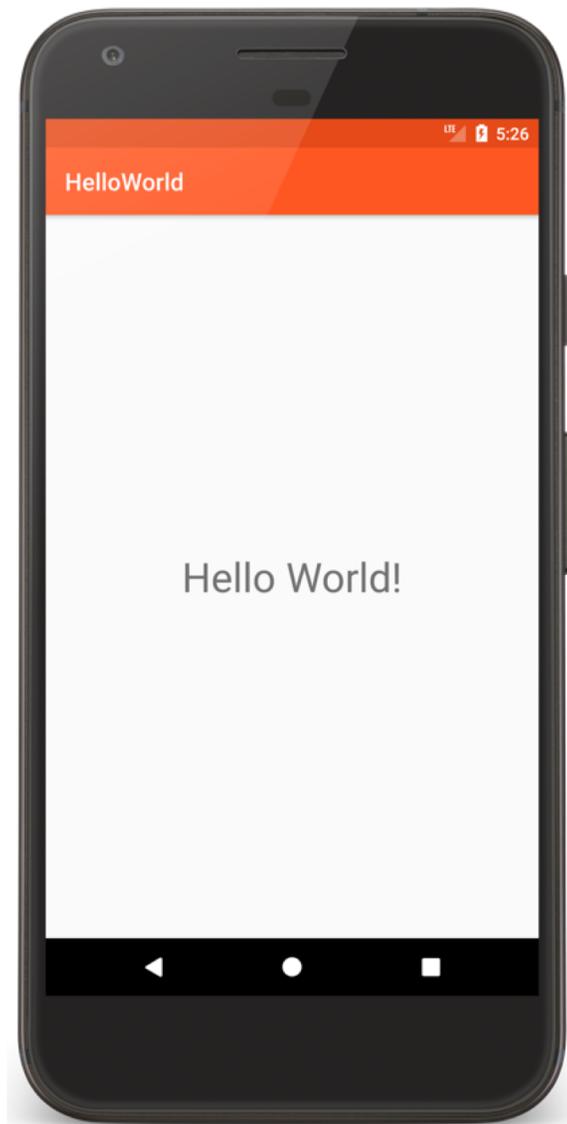
Android platform

Android Studio IDE

Key development tools

System image for emulator

HelloWorld



```
package course.examples.helloworld;
```

```
...
```

```
public class MainActivity extends Activity {
```

```
    @Override
```

```
    protected void onCreate(Bundle savedInstanceState) {
```

```
        super.onCreate(savedInstanceState);
```

```
        setContentView(R.layout.activity_main);
```

```
    }
```

```
}
```

# The Android Emulator

Runs virtual devices

Project Structure

- app
  - manifests
    - AndroidManifest.xml
  - java
    - course.examples.helloworld
      - MainActivity
  - res
    - layout
      - activity\_main.xml
    - mipmap
    - values
      - colors.xml
      - dimens.xml
      - strings.xml
      - styles.xml
  - Gradle Scripts
    - build.gradle (Module: app)
    - gradle-wrapper.properties (Gradle V)
    - proguard-rules.pro (ProGuard Rules)
    - gradle.properties (Project Properties)
    - settings.gradle (Project Settings)
    - local.properties (SDK Location)

### Your Virtual Devices

Android Studio

Type	Name	Play Store	Resolution	API	Target	CPU/ABI	Size on Disk	Actions
	Galaxy Nexus API 18		720 x 1280: xhdpi	18	Android 4.3 (Google APIs)	x86	4 GB	Download
	Galaxy Nexus API 22		720 x 1280: xhdpi	22	Android 5.1 (Google APIs)	x86	1 GB	▶ ✎
	Nexus7_API 18		800 x 1280: tvdpi	18	Android 4.3	arm	123 MB	Download
	Nexus 5 API 22 v1		1080 x 1920: xxhdpi	22	Android 5.1 (Google APIs)	x86	1 GB	▶ ✎
	Nexus 5 API 22 v2		1080 x 1920: xxhdpi	22	Android 5.1 (Google APIs)	x86	1 GB	▶ ✎
	Nexus 5X API 23 New		1080 x 1920: 420dpi	23	Android 6.0 (Google APIs)	x86	1 GB	▶ ✎
	Pixel API 26		1080 x 1920: xxhdpi	26	Android 8.0 (Google APIs)	x86	2 GB	▶ ✎
	Pixel XL API 26		1440 x 2560: 560dpi	26	Android 8.0 (Google APIs)	x86	1 GB	▶ ✎

ⓘ + Create Virtual Device...

Messages: Gradle Build Code Analysis

- Warning:(5, 6) On SDK v...
- Warning:(5, 6) App is no...

Device File Explorer

which files to backup. More info:

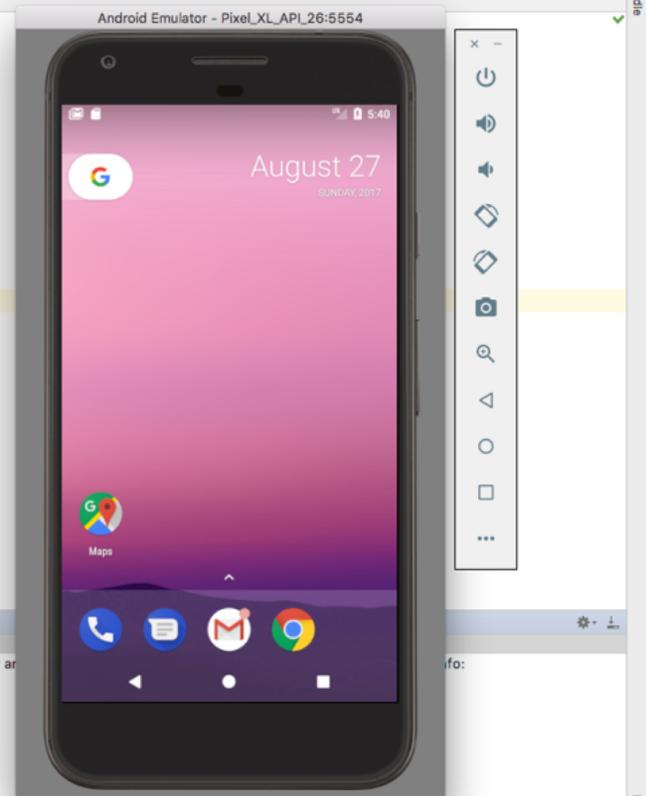
```
1 package course.examples.helloworld;
```

### Your Virtual Devices

Android Studio

Type	Name	Play Store	Resolution	API	Target	CPU/ABI	Size on Disk	Actions
	Galaxy Nexus API 18		720 x 1280: xhdpi	18	Android 4.3 (Google APIs)	x86	4 GB	Download
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	Nexus7_API 18		800 x 1280: tvdpi	18	Android 4.3	arm	123 MB	Download
	Nexus 5 API 22 v1		1080 x 1920: xxhdpi	22	Android 5.1 (Google APIs)	x86	1 GB	
	Nexus 5 API 22 v2		1080 x 1920: xxhdpi	22	Android 5.1 (Google APIs)	x86	1 GB	
	Nexus 5X API 23 New		1080 x 1920: 420dpi	23	Android 6.0 (Google APIs)	x86	1 GB	
	Pixel API 26		1080 x 1920: xxhdpi	26	Android 8.0 (Google APIs)	x86	2 GB	
	Pixel XL API 26		1440 x 2560: 560dpi	26	Android 8.0 (Google APIs)	x86	1 GB	

[+ Create Virtual Device...](#)



# The Android Emulator

## Pros

Doesn't require an actual phone

Hardware is reconfigurable

Changes are non-destructive

# The Android Emulator

## Cons

Slower than an actual device

Some features unavailable

e.g., no support for Bluetooth, USB connections, NFC, etc.

Performance / user experience can be misleading

# Advanced Features

Can emulate many different device/user characteristics, such as:

- Network speed/latencies

- Battery power

- Location coordinates

# Advanced Features

Change network speeds

### Extended controls

- Location
- Cellular**
- Battery
- Phone
- Directional pad
- Microphone
- Fingerprint
- Virtual sensors
- Bug report
- Settings
- Help

Network type	EDGE	Signal strength	Moderate
Voice status	Home	Data status	Home



- Close (x)
- Maximize (-)
- Power
- Volume
- Microphone
- Rotation
- Camera
- Search
- Navigation (triangle)
- Home (circle)
- Recent apps (square)
- More options (three dots)

# Advanced Features

Emulate incoming phone calls & SMS messages

### Extended controls

- Location
- Cellular
- Battery
- Phone
- Directional pad
- Microphone
- Fingerprint
- Virtual sensors
- Bug report
- Settings
- Help

From (650) 555-1212

HOLD CALL CALL DEVICE

SMS message

Nougat is sweet!

SEND MESSAGE

### Android Emulator - Pixel\_XL\_API\_26:5554

Messages · now

(650) 555-1212

Nougat is sweet!

MARK AS READ REPLY

Maps

Phone, Messages, Gmail, Chrome

- Power
- Volume
- Microphone
- Rotation
- Camera
- Search
- Navigation
- Home
- Recent apps
- More

Extended controls

- Location
- Cellular
- Battery
- Phone
- Directional pad
- Microphone
- Fingerprint
- Virtual sensors
- Bug report
- Settings
- Help

From (650) 555-1212

HOLD CALL    END CALL

SMS message

Nougat is sweet!

SEND MESSAGE

Android Emulator - Pixel\_XL\_API\_26:5554

(650) 555-1212  
00:01

Mute    Keypad    Speaker

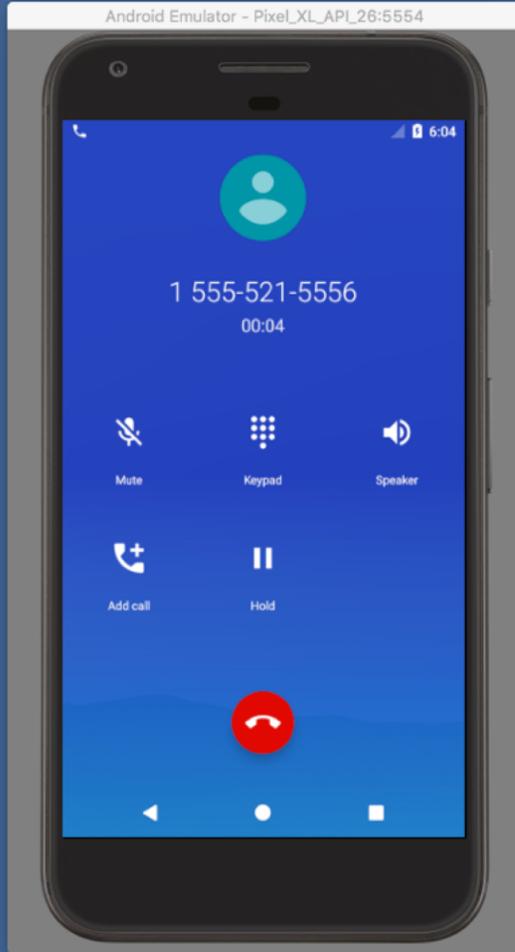
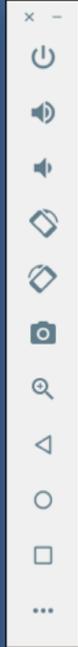
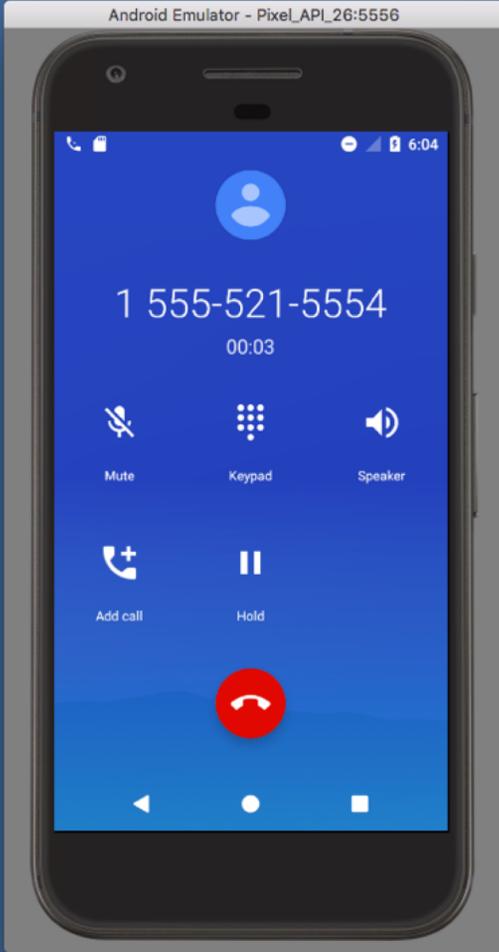
Add call    Hold

- Power
- Volume
- Microphone
- Camera
- Keypad
- Search
- Navigation
- Home
- Recent apps
- More

# The Android Emulator

Can interconnect multiple emulators





# Advanced Features

Many more options

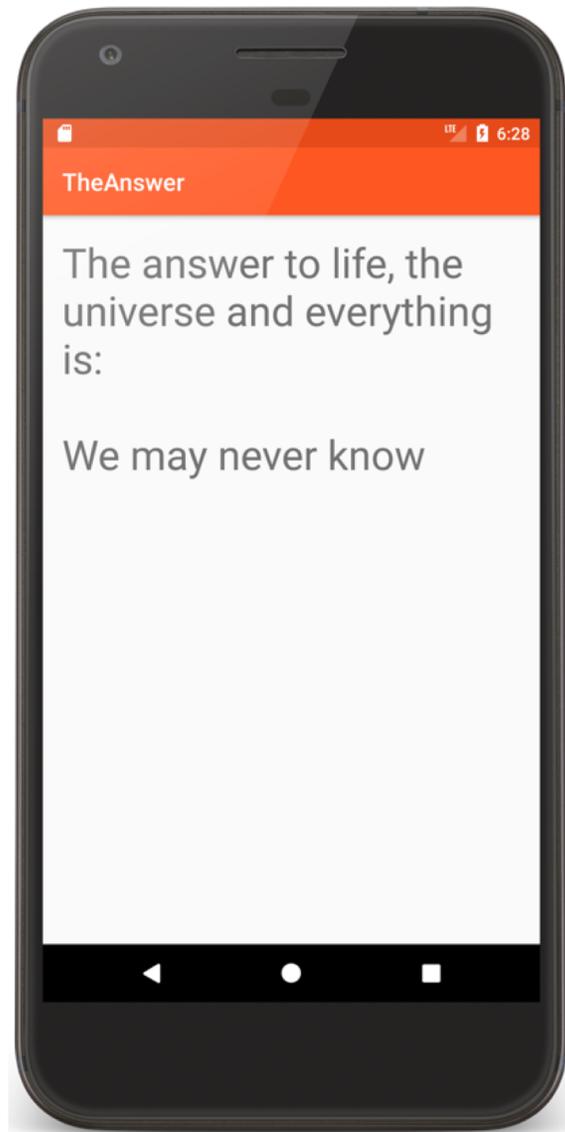
See:

<https://developer.android.com/studio/run/emulator.html>

# Debugger

Tool for examining the internal state of a running application

TheAnswer



```
public class TheAnswer extends Activity {  
  
    private static final int[] answers = { 42, -10, 0, 100, 1000 };  
    private static final int answer = 42;  
  
    @Override  
    protected void onCreate(Bundle savedInstanceState) {  
  
        // Required call through to Activity.onCreate()  
        super.onCreate(savedInstanceState);  
  
        // Set up the application's user interface (content view)  
        setContentView(R.layout.answer_layout);  
  
        // Get a reference to a TextView in the content view  
        TextView answerView = findViewById(R.id.answer_view);  
    }  
}
```

```
    ""
    int val = findAnswer();
    String output = (val == answer) ? "42" : "We may never know";

    // Set desired text in answerView TextView
    answerView.setText(String.format("The answer to life,
                                     the universe and everything is:\n\n%s", output));
}

private int findAnswer() {
    for (int val : answers) {
        if (val != answer)
            return val;
    }
    return -1;
}
}
```



# Development Tools

Android Studio provides numerous tools for monitoring application behaviors

# Example Tools

Device File Explorer

Logcat

CPU Profiler

Layout Inspector

# Device File Explorer

View, copy, and delete files on your device

Often used to examine and verify file creation and transfer

Added in Android Studio 3.0

Android Studio 3.0 Beta 2

File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help

Tool Windows

- Recent Files ⌘E
- Recently Changed Files ⇧⌘E
- Recent Changes ⇧⇧C
- Compare with Clipboard
- Quick Switch Scheme...
- ✓ Toolbar
- ✓ Tool Buttons
- ✓ Status Bar
- ✓ Navigation Bar
- Bidi Text Direction
- Enter Presentation Mode
- Enter Distraction Free Mode
- Exit Full Screen ⇧⌘F

- Project ⌘1
- Favorites ⌘2
- Run ⌘4
- Debug ⌘5
- Logcat ⌘6
- Structure ⌘7
- Version Control ⌘9
- Android Profiler
- Build Variants
- Capture Analysis
- Capture Tool
- Captures
- Designer
- Device File Explorer
- Event Log
- Gradle
- Gradle Console
- Image Layers
- Palette
- Terminal ⌘F12
- Theme Preview
- TODO

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38
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41
```

```

super.onCreate()
// Set up the content view
setContentView(R.layout.activity_main);

// Get a reference to a TextView in the content view
TextView answerView = findViewById(R.id.answer_view);

int val = findAnswer();
String output = (val == answer) ? String.valueOf(answer) : "We may never know";

// Set desired text in answerView TextView
answerView
    .setText(output);
}

private int findAnswer() {
    for (int val : answers) {
        if (val == answer)
            return val;
    }
    return -1;
}
}
```

The screenshot shows an IDE with two main panels. The left panel displays the Java code for an Android activity named 'TheAnswer'. The code includes imports, class definition, and methods for handling onCreate and finding answers. The right panel shows the 'Device File Explorer' for an emulator named 'Emulator Pixel\_XL\_API\_26 Android 8.0.0, API 26'. It lists various system and application files, with 'course.examples.theanswer' highlighted.

```
3 import ...
6
7 public class TheAnswer extends Activity {
8
9     private static final int[] answers = { 42, -10,
10     private static final int answer = 42;
11
12     @Override
13     protected void onCreate(Bundle savedInstanceState) {
14
15         // Required call through to Activity.onCreate
16         // Restore any saved instance state
17         super.onCreate(savedInstanceState);
18
19         // Set up the application's user interface
20         setContentView(R.layout.answer_layout);
21
22         // Get a reference to a TextView in the content view
23         TextView answerView = findViewById(R.id.answer_text);
24
25         int val = findAnswer();
26         String output = (val == answer) ? String.valueOf(val) : "No answer found";
27
28         // Set desired text in answerView TextView
29         answerView
30             .setText(output);
31     }
32
33     private int findAnswer() {
34         for (int val : answers) {
35             if (val == answer)
36                 return val;
37         }
38         return -1;
39     }
40 }
41
```

Name	Per...	Date	Size
com.google.android.configupdater	drwx-	2017-08-26 23:24	4 KB
com.google.android.dialer	drwx-	2017-08-26 23:24	4 KB
com.google.android.ext.services	drwx-	2017-08-26 23:24	4 KB
com.google.android.ext.shared	drwx-	2017-08-26 23:24	4 KB
com.google.android.feedback	drwxr	2017-08-26 23:24	4 KB
com.google.android.gm	drwx-	2017-08-27 00:13	4 KB
com.google.android.gms	drwxr	2017-08-27 18:27	4 KB
com.google.android.googlequicksearchbox	drwx-	2017-08-27 18:27	4 KB
com.google.android.gsf	drwx-	2017-08-27 18:27	4 KB
com.google.android.music	drwx-	2017-08-27 00:13	4 KB
com.google.android.onetimeinitializer	drwx-	2017-08-26 23:24	4 KB
com.google.android.partnersetup	drwx-	2017-08-26 23:24	4 KB
com.google.android.setupwizard	drwx-	2017-08-26 23:25	4 KB
com.google.android.syncadapters.contacts	drwxr	2017-08-27 00:13	4 KB
com.google.android.talk	drwx-	2017-08-27 18:27	4 KB
com.google.android.tts	drwx-	2017-08-27 18:27	4 KB
com.google.android.videos	drwx-	2017-08-27 18:27	4 KB
com.google.android.webview	drwx-	2017-08-26 23:24	4 KB
com.google.android.youtube	drwx-	2017-08-27 18:27	4 KB
com.us.two.lwp	drwx-	2017-08-26 23:24	4 KB
course.examples.theanswer	drwx-	2017-08-27 18:27	4 KB
jp.co.omronsoft.openwnn	drwx-	2017-08-27 18:27	4 KB
org.chromium.webview_shell	drwx-	2017-08-26 23:24	4 KB
drm	drwxr	2017-08-26 23:23	4 KB
local	drwxr	2017-08-26 23:23	4 KB
lost+found	drwxr	1969-12-31 19:00	4 KB
media	drwxr	2017-08-26 23:24	4 KB
mediadr	drwxr	2017-08-26 23:23	4 KB
misc	drwxr	2017-08-26 23:23	4 KB
misc_ce	drwxr	2017-08-26 23:24	4 KB
misc_de	drwxr	2017-08-26 23:23	4 KB
nativetest	drwxr	2017-08-26 23:23	4 KB
ota	drwxr	2017-08-26 23:23	4 KB
ota_package	drwxr	2017-08-26 23:23	4 KB
property	drwx-	2017-08-27 18:27	4 KB
resource-cache	drwxr	2017-08-26 23:23	4 KB
ss	drwx-	2017-08-26 23:23	4 KB
system	drwxr	2017-08-28 10:02	4 KB
system_ce	drwxr	2017-08-26 23:24	4 KB
system_de	drwxr	2017-08-26 23:23	4 KB
tombstones	drwxr	2017-08-26 23:23	4 KB
user	drwx-	2017-08-26 23:23	4 KB
user_de	drwx-	2017-08-26 23:23	4 KB
vendor	drwxr	2017-08-26 23:23	4 KB

# Logcat

Write and review log messages

Apps use Log class to write messages to log

Developer can search and filter log messages

The screenshot displays an IDE window with the following components:

- Project Explorer:** Shows the project structure for 'The Answer', including 'app', 'Gradle Scripts', 'build.gradle', 'gradle-wrapper.properties', 'settings.gradle', and 'local.properties'.
- Code Editor:** Displays the `findAnswer()` method in `TheAnswer.java`. The code is as follows:

```
22 setContentView(R.layout.answer_layout);
23
24 // Get a reference to a TextView in the content view
25 TextView answerView = findViewById(R.id.answer_view);
26
27 int val = findAnswer();
28 String output = (val == answer) ? String.valueOf(answer) : "We may never know";
29
30 // Set desired text in answerView TextView
31 answerView
32     .setText(output);
33 }
34
35 private int findAnswer() {
36     Log.d(TAG, msg: "Entering findAnswer()");
37     for (int val : answers) {
38         if (val != answer)
39             return val;
40     }
41     Log.e(TAG, msg: "Unexpected behavior");
42     return -1;
43 }
44 }
45 }
```
- Logcat:** Shows system logs for the emulator 'Emulator Pixel\_XL\_API\_26 Android 8.0.0, API 26'. The logs include:
  - 08-28 10:28:04.736 10297-10297/? W/zygote: Unexpected CPU variant for X86 using defaults: x86
  - 08-28 10:28:05.174 10297-10297/course.examples.theanswer I/InstantRun: starting instant run server: is main process
  - 08-28 10:28:05.324 10297-10297/course.examples.theanswer D/TheAnswer: Entering findAnswer()
  - 08-28 10:28:05.485 10297-10324/course.examples.theanswer D/OpenGLRenderer: HWUI GL Pipeline
  - 08-28 10:28:05.829 10297-10324/course.examples.theanswer I/OpenGLRenderer: Initialized EGL, version 1.4
  - 08-28 10:28:05.829 10297-10324/course.examples.theanswer D/OpenGLRenderer: Swap behavior 1
  - 08-28 10:28:05.829 10297-10324/course.examples.theanswer W/OpenGLRenderer: Failed to choose config with EGL\_SWAP\_BEHAVIOR\_PRESERVED, retrying with
  - 08-28 10:28:05.829 10297-10324/course.examples.theanswer D/OpenGLRenderer: Swap behavior 0
  - 08-28 10:28:05.836 10297-10324/course.examples.theanswer D/EGL\_emulation: eglCreateContext: 0xa68ff280: maj 2 min 0 rcv 2
  - 08-28 10:28:05.837 10297-10324/course.examples.theanswer D/EGL\_emulation: eglMakeCurrent: 0xa68ff280: ver 2 0 (tinfo 0xa66a3a00)

```
22     setContentView(R.layout.answer_layout);
23
24     // Get a reference to a TextView in the content view
25     TextView answerView = findViewById(R.id.answer_view);
26
27     int val = findAnswer();
28     String output = (val == answer) ? String.valueOf(answer) : "We may never know";
29
30     // Set desired text in answerView TextView
31     answerView
32         .setText(output);
33 }
34
35 private int findAnswer() {
36     Log.d(TAG, msg: "Entering findAnswer()");
37     for (int val : answers) {
38         if (val != answer)
39             return val;
40     }
41     Log.e(TAG, msg: "Unexpected behavior");
42     return -1;
43 }
44 }
45
```

Logcat  
Emulator Pixel\_XL\_API\_26 Android 8.0.0, API 26 course.examples.theanswer (10297) Verbose Q- Entering  Regex Show only selected application

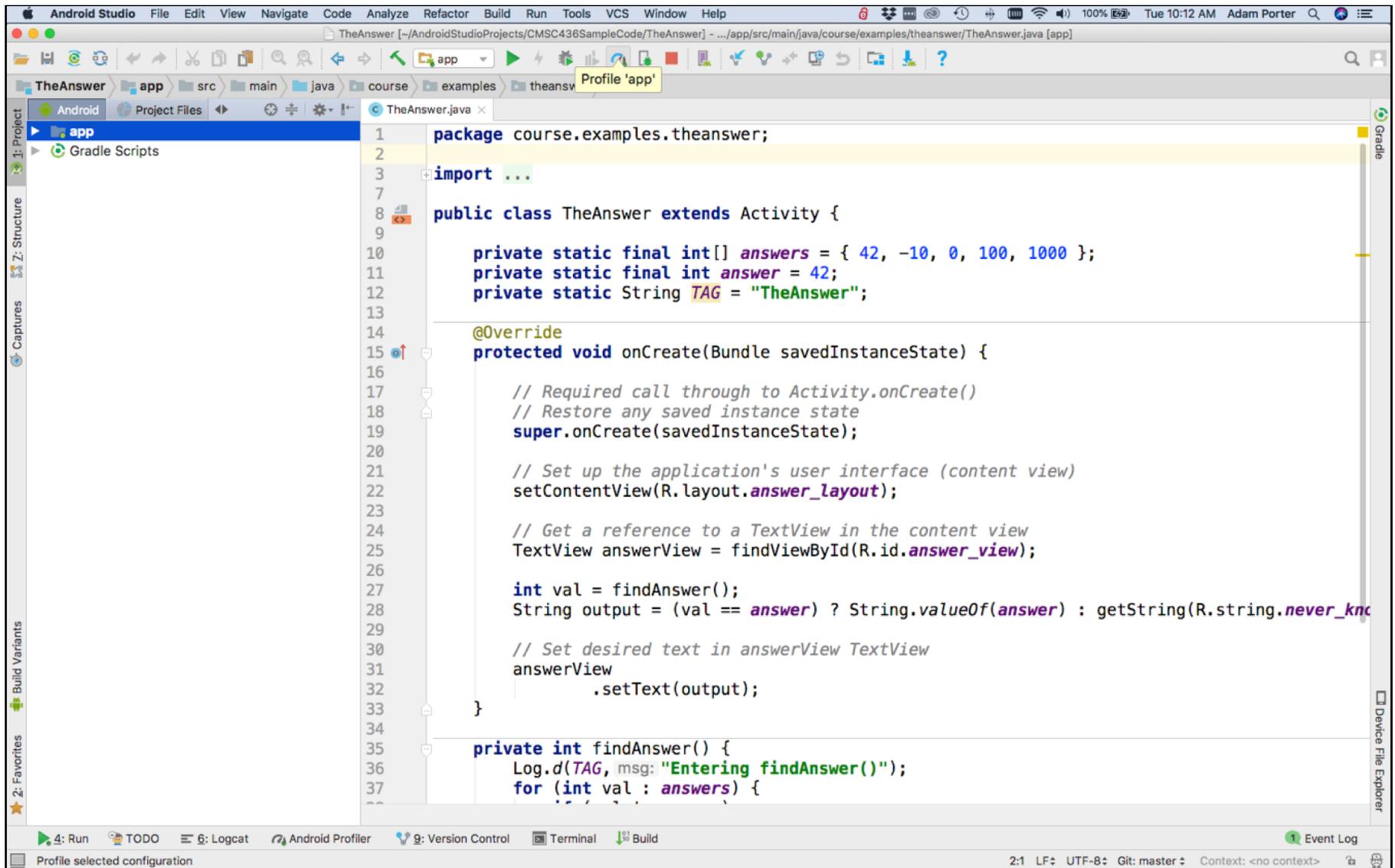
08-28 10:28:05.324 10297-10297/course.examples.theanswer D/TheAnswer: Entering findAnswer()

Build Variants  
Z: Favorites  
Device File Explorer

# CPU Profiler

Logs execution sequences and timing taken from a running application

Graphically displays method traces and metrics



Android Studio File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help

TheAnswer [-/AndroidStudioProjects/CMSC436SampleCode/TheAnswer] - .../app/src/main/java/course/examples/theanswer/TheAnswer.java [app]

TheAnswer app src main java course examples theanswer

Android Profiler CPU Instrumented (Java) End Session Live

CPU App: 0% Others: 25% Threads: 11

00:00:07.703 - 00:00:18.688

Captures mples.theanswer Binder:5698\_1 RenderThread Studio:Agent Studio:Socket Studio:Heartbeat Thread-3 Thread-6 JVMTI Agent thr JVMTI Agent thr

Call Chart Flame Chart Top Down Bottom Up Wall Clock Time 00:00:07.703 - 00:00:18.688

android.os.MessageQueue.next	android.os.Handler.dispatchMessage	dispatchMe...	dis...	next	n...	...	android.os.MessageQueue.next
android.os.MessageQueue.nativePollOnce	android.app.ActivityThread\$H.handleMessage	handleCall...	ha...	na...	n...	...	android.os.MessageQueue.nativePollOnce
	android.app.ActivityThread.wrap11	a.v.C.run	run				
	android.app.ActivityThread.handleLaunchActivity	doFrame	do...				
	a.app.ActivityThread.performLaunchActivity	handle...	doCallbacks	do...			
	cr... s... a.a.i.callActivityOnCreate	addView	a.v.C.run	run			
	cr... s... android.app.Activity.performCreate	addView	a.v.V.run	run			
	cr... in... e.e.theanswer.TheAnswer.onCreate	setVi...	doTraversal	do...			
	g... o... android.app.Activity.setContentView	perform Tra...	perform Tra...	per...			
	Cr... c.a.i.p.setContentView	f...	f...	pe...			
	g... c.a.i.p.installDecor	infl...	f...	f...			
	g... generateLayout	getDef...	infl...	f...			
	u... r... onResourcesLo...	getDra...	infl...	f...			
	g... a.v.L.inflate	getDra...	rln...	f...			
	g... a.v.L.inflate	getDra...	rln...	f...			
	t... a.v.L.inflate	loadDr...	cre...	f...			
	rInflateChildren	loadDr...	cre...	f...			
	a.v.L.Inflate	create...	on...	f...			
	cr... rInfla...	create...	on...	f...			

4: Run TODO 6: Logcat Android Profiler Version Control Terminal Build Event Log

Gradle build finished in 2s 815ms (2 minutes ago) 2:1 LF: UTF-8: Git: master Context: <no context>

Android Studio File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help

TheAnswer [-/AndroidStudioProjects/CMSC436SampleCode/TheAnswer] - .../app/src/main/java/course/examples/theanswer/TheAnswer.java [app]

TheAnswer app src main java course examples theanswer

Android Profiler CPU Instrumented (Java) End Session Live

CPU 100% 50% 0m 5.00s 10.00s 15.00s 20.00s

TheAnswer App: 2% Others: 13% Threads: 11

Captures mplex.theanswer Binder:5698\_1 RenderThread Studio:Agent Studio:Socket Studio:Heartbea Thread-3 Thread-6 JVMTI Agent thr JVMTI Agent thr

Call Chart Flame Chart Top Down Bottom Up Wall Clock Time 00:00:07.703 - 00:00:18.688

findAnswer Match Case Regex

Name	Total (µs)	%	Self (µs)	%	Children (µs)	%
m main() ()	10,852,275	100.00	323	0.00	10,851,952	100.00
▶ m dispatchMessage() (android.os.Handler)	2,493,396	22.98	6	0.00	2,493,390	22.98
▶ m handleMessage() (android.app.ActivityThread\$H)	2,493,390	22.98	75	0.00	2,493,315	22.98
▶ m -wrap11() (android.app.ActivityThread)	2,492,460	22.97	15	0.00	2,492,445	22.97
▶ m handleLaunchActivity() (android.app.ActivityThread)	2,492,445	22.97	113	0.00	2,492,332	22.97
▶ m performLaunchActivity() (android.app.ActivityThread)	2,072,148	19.09	607	0.01	2,071,541	19.09
▶ m callActivityOnCreate() (android.app.Instrumentation)	1,571,405	14.48	15	0.00	1,571,390	14.48
▶ m performCreate() (android.app.Activity)	1,571,376	14.48	20	0.00	1,571,356	14.48
▶ m onCreate() (course.examples.theanswer.TheAnswer)	1,570,768	14.47	25	0.00	1,570,743	14.47
▶ m findAnswer() (course.examples.theanswer.TheAnswer)	76	0.00	11	0.00	65	0.00
▶ m d() (android.util.Log)	65	0.00	12	0.00	53	0.00
▶ m println_native() (android.util.Log)	53	0.00	53	0.00	0	0.00

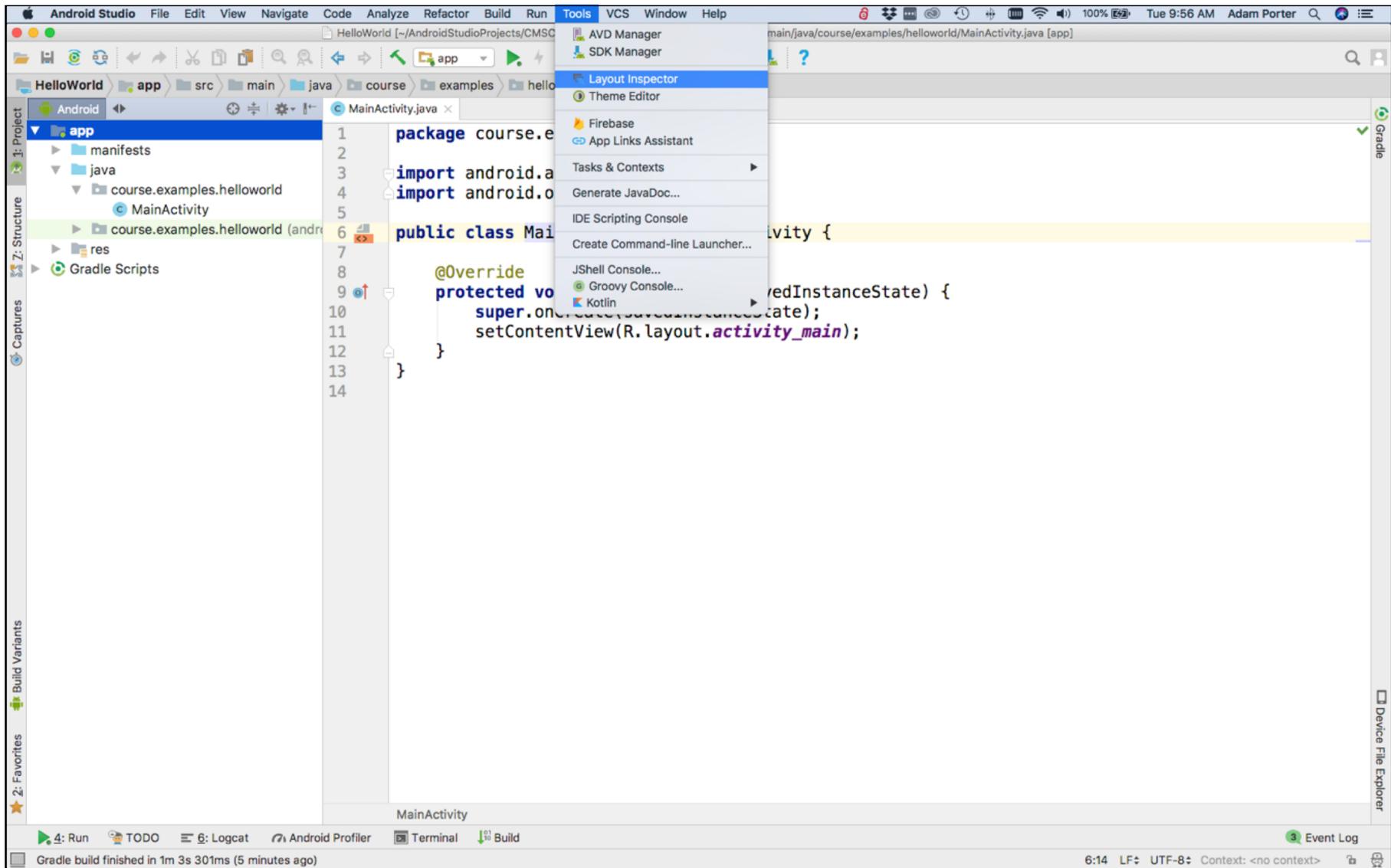
Build Variants Favorites

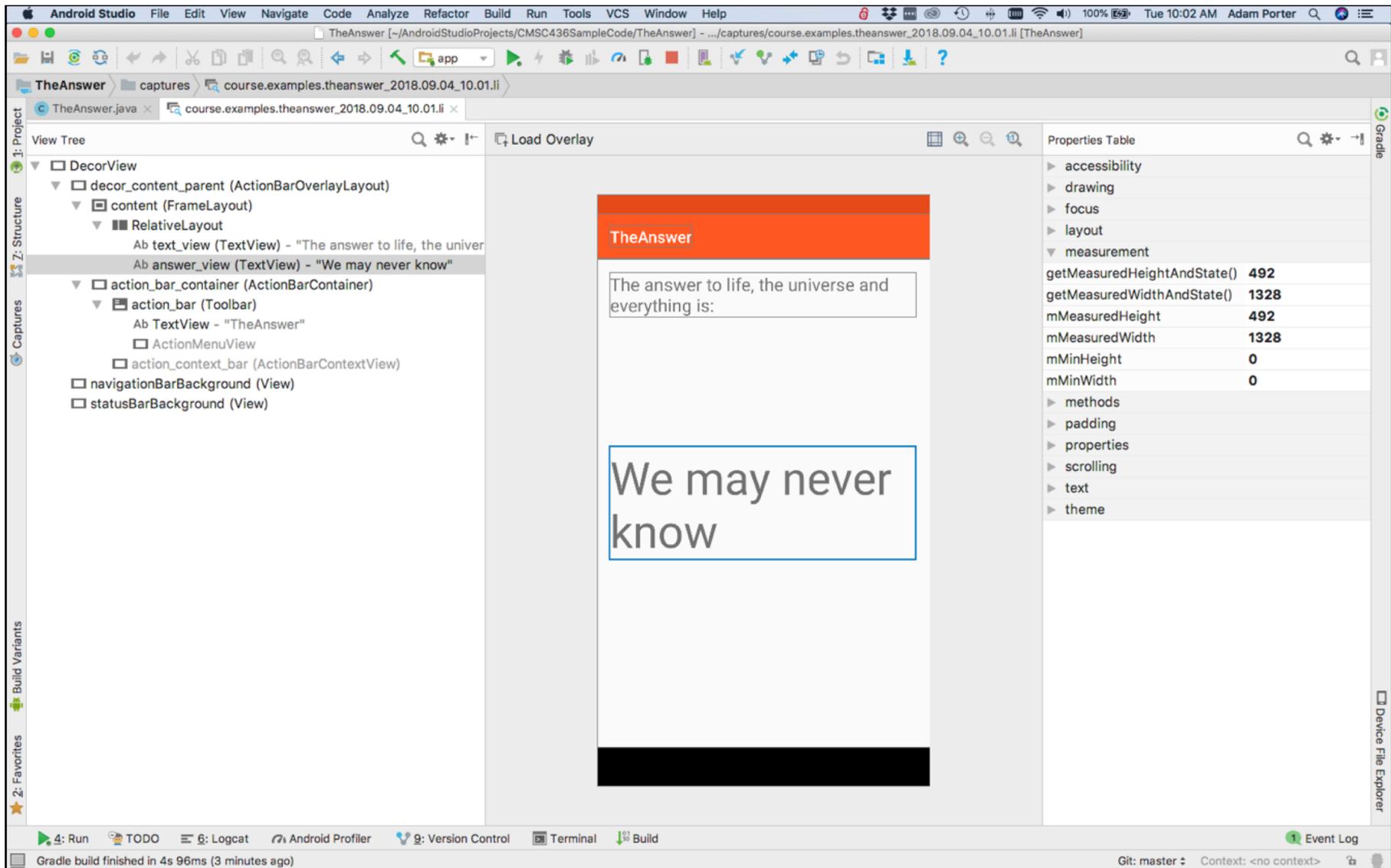
Run TODO Logcat Android Profiler Version Control Terminal Build Event Log

Gradle build finished in 2s 815ms (3 minutes ago) 2:1 LF: UTF-8: Git: master Context: <no context>

# Layout Inspector

Shows the runtime organization of the user interface





**Next**

Application Fundamentals

# Example Applications

HelloWorld

TheAnswer