Application Development

Lecture 1
Introduction to Flutter & Cross-Platform App Development

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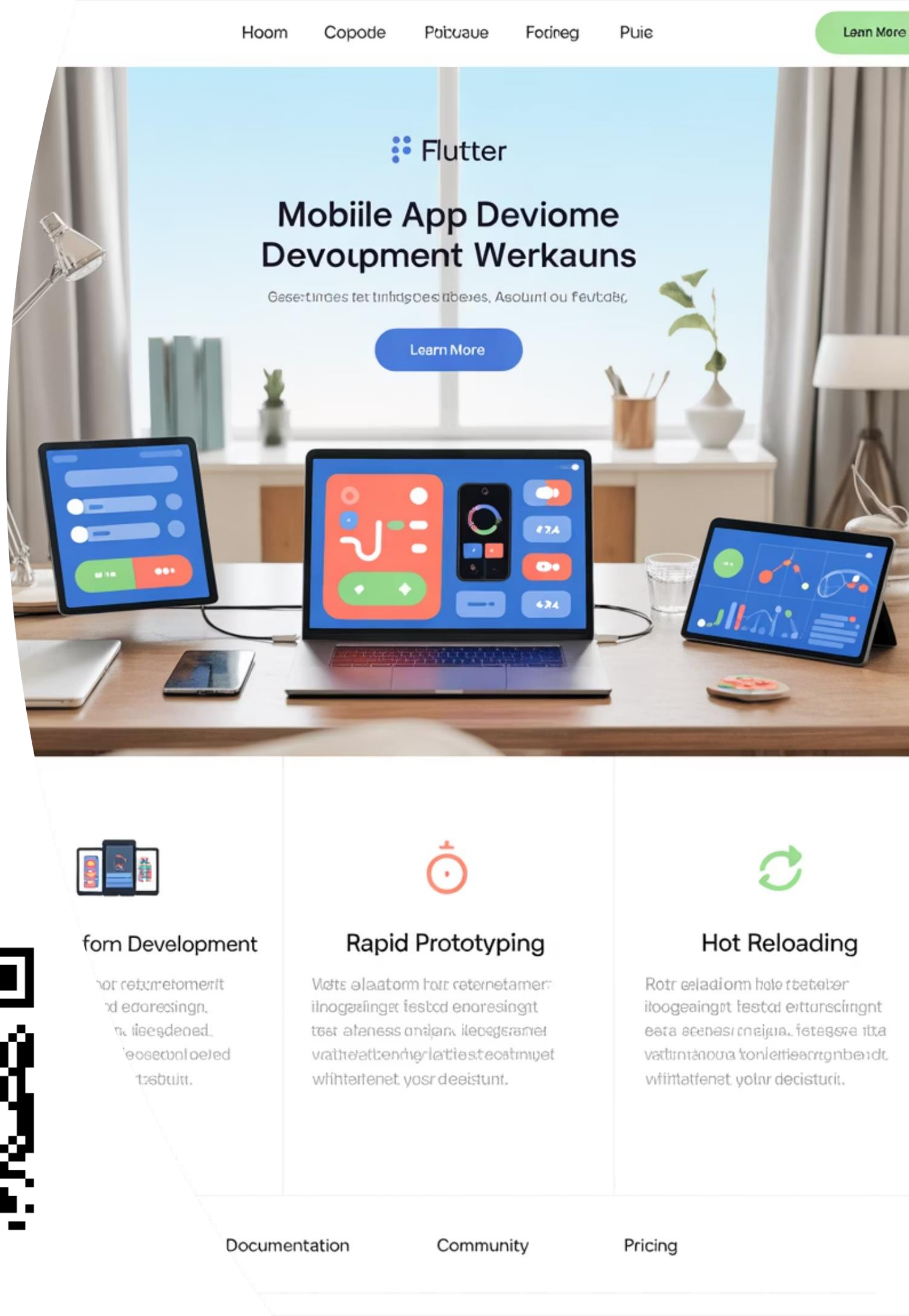
Class Room



Welcome & Course Context

Warm Welcome

Welcome to *Application Development (Flutter)*. This course will transform how you think about mobile development, teaching you to create powerful apps that work seamlessly across multiple platforms.

Purpose of Today

We'll introduce the course structure, explain its critical importance in today's mobile-driven world, and provide a detailed understanding of cross-platform development principles that will guide your learning journey.

Big Picture Vision

By course completion, you'll master how a single Dart codebase can create high-quality apps for Android, iOS, Web, and Desktop—revolutionising your development workflow and career prospects.

General Course Objective

To equip students with the theoretical knowledge and practical skills to design, develop, and deploy cross-platform mobile applications using the **Flutter framework** and **Dart programming language**, whilst strengthening problem-solving abilities, teamwork, and professional software-engineering practices.

This comprehensive objective encompasses both technical mastery and professional development skills essential for modern software engineering careers. You'll learn to think systematically about application architecture whilst developing the collaborative skills valued by industry employers.

Why This Course Matters

Market Reality

Companies need fast, cost-effective delivery on multiple platforms. The ability to develop once and deploy everywhere has become a competitive advantage that employers actively seek in new graduates.

User Experience

Consistent UI/UX across devices is no longer optional—it's expected. Users demand seamless experiences whether they're on Android, iOS, or web platforms.

Career Edge

Skills in Flutter and Dart are highly valued by employers and essential for start-up product development. This course positions you at the forefront of modern app development.

Learning Outcomes for This Lecture

By the end of this lecture, you will demonstrate mastery of fundamental cross-platform development concepts and be prepared to begin hands-on Flutter development.

1 **Cross-Platform Understanding**

Explain cross-platform development and its technical motivations, including performance trade-offs and business benefits.

2 **Flutter Architecture**

Describe Flutter's architecture and its major components, understanding how they work together to deliver native-like performance.

3 **Environment Setup**

List and sequence the steps to set up the Flutter environment, ensuring you're prepared for upcoming practical sessions.

4 **Active Participation**

Participate effectively in all class activities within a blended-learning model, developing collaboration skills essential for software development teams.

Lecture Contents

Concept of Cross-Platform Development

Definition

Build a single application capable of running on multiple operating systems—Android, iOS, Web, Desktop—using **one unified codebase**.

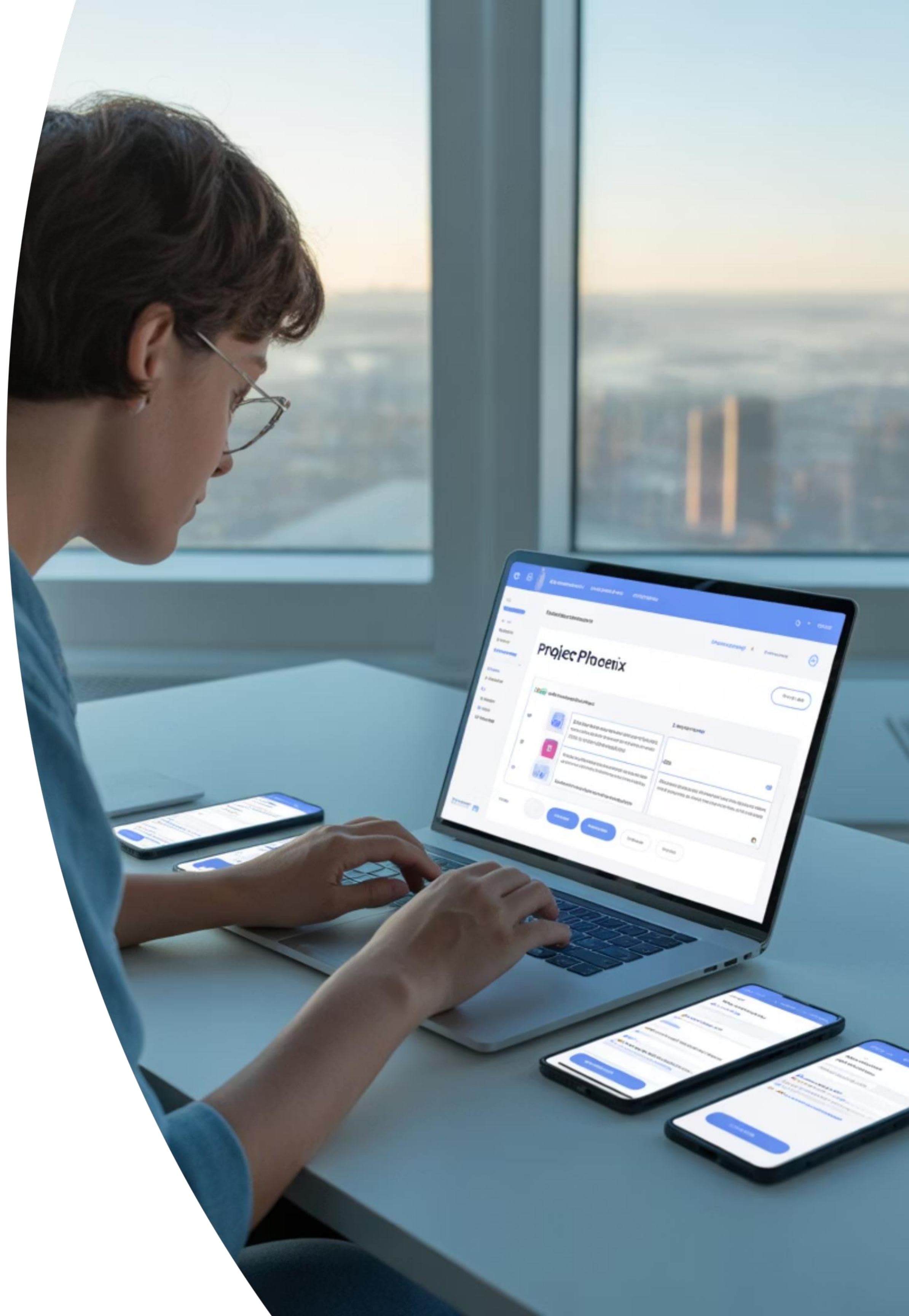
Philosophy

"Write once, deploy everywhere."

This paradigm shift revolutionises traditional development approaches, eliminating the need to maintain separate codebases for different platforms whilst preserving native-like performance and user experience.

Primary Goal

- Faster delivery cycles
- Reduced development costs
- Consistent user experience
- Simplified maintenance



Why Businesses Need Cross-Platform Apps

Rapid Release Cycles

Achieve shorter time-to-market by eliminating duplicate development efforts. Deploy updates simultaneously across all platforms, maintaining competitive advantage.

Consistent UI/UX

Deliver unified user experiences across diverse devices and operating systems. Brand consistency strengthens user recognition and satisfaction.

Lower Maintenance

Avoid the complexity and cost of maintaining two separate native codebases. Bug fixes and feature updates require half the development effort.

These advantages translate directly into reduced development costs, faster market entry, and improved resource allocation—critical factors for both established companies and start-ups competing in today's fast-paced digital marketplace.

Native vs. Cross-Platform Development

Aspect	Native Development	Cross-Platform Development
Codebase	Separate code for Android & iOS	Single shared codebase
Performance	Highest possible performance	Near-native performance
Development Cost	Longer development & higher cost	Faster, more cost-efficient
Maintenance	Duplicate effort required	Unified maintenance approach
Time to Market	Slower due to parallel development	Significantly faster deployment

Key Insight: Flutter narrows the performance gap whilst preserving speed and cost advantages. Modern cross-platform frameworks achieve 95%+ native performance for most use cases.

1. Major Frameworks Overview

1. Flutter (Google)

1. **Focus of this course.** Dart-based framework with exceptional performance and rich widget library. Compiles to native machine code.

1. React Native (Meta)

1. JavaScript-based framework leveraging React concepts. Strong community support but performance limitations compared to Flutter.

1. Xamarin (.NET)

1. Microsoft's C#-based solution. Excellent for enterprises already invested in .NET ecosystem but more complex setup.

1. Ionic & Kotlin Multiplatform

1. Web-based (Ionic) and Kotlin-based solutions offering different approaches to cross-platform challenges with varying trade-offs.

Activity 1 – Brainstorming (5 minutes)

"List the biggest challenges developers face when creating apps for multiple platforms."

What Is Flutter?

Definition and Origin

An open-source UI framework launched by Google in 2017, aiming to revolutionize the way beautiful and custom-designed native applications (Natively Compiled) are built for mobile, web, and desktop, all from a single codebase.

Comprehensive and Integrated Scope

Flutter enables you to build applications for Android, iOS, web, and desktop platforms from a **single Dart codebase**. This eliminates the complexities associated with platform-specific development while maintaining native performance standards.

Programming Model

- **Declarative:** Defines how the user interface should look, not how it is drawn.
- **Widget-based:** Every element in Flutter is a composable widget.
- **Reactive:** The UI automatically updates with data changes to provide a seamless experience.

Key Competitive Advantage

Unlike other frameworks that rely on web views or platform-specific native components, Flutter renders directly to the screen using its high-performance rendering engine, ensuring exceptional speed and performance.

Key Advantages of Flutter

Single Codebase

Write once, run everywhere. Eliminate duplicate development efforts whilst maintaining platform-specific optimisations and native integrations where needed.

Hot Reload & Hot Restart

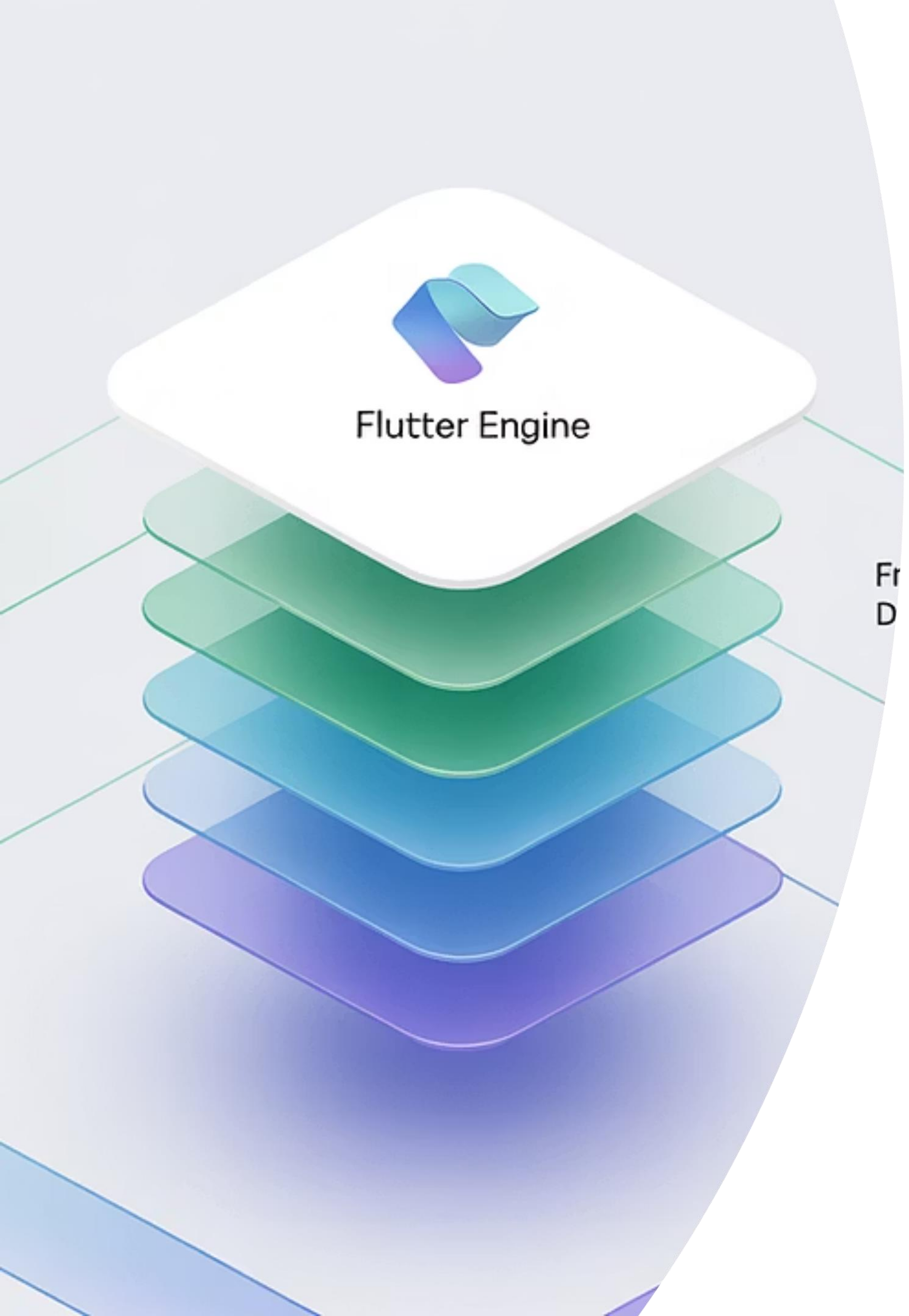
Instantly reflect UI changes during development. See code modifications in milliseconds, dramatically accelerating the development and debugging process.

Native-Like Performance

Compiles to ARM machine code, delivering 60fps animations and smooth user interactions that rival native applications in performance benchmarks.

Rich Widget Library

Material and Cupertino widgets for beautiful interfaces. Extensive customisation options enable unique designs whilst maintaining platform conventions.



Flutter Architecture Overview

Flutter Engine

High-performance rendering and graphics powered by Skia. Written in C++ for optimal performance, handles low-level rendering, text layout, and file system access.

Framework Layer

Widgets, rendering, animation, and gestures. Provides the reactive programming model and composable widget system that makes Flutter development intuitive and powerful.

Dart Runtime

Just-In-Time (JIT) compilation for development hot reload, Ahead-Of-Time (AOT) compilation for optimised release builds ensuring maximum performance in production.

Platform Channels

Bidirectional communication with native APIs. Enables access to platform-specific features like camera, GPS, and notifications whilst maintaining code sharing benefits.

Flutter Engine in Detail

Core Implementation

Implemented in C++ for high-performance rendering, the Flutter Engine serves as the foundation that enables Flutter's exceptional performance characteristics across all supported platforms.

Skia Integration

Integrates with Skia graphics library to accelerate rendering and manage complex layer compositions. This integration ensures consistent visual output across different platforms and devices.

Key Responsibilities

- Text layout and typography rendering
- 2D graphics acceleration and compositing
- 60fps animation management
- Platform-specific adaptations

Performance Benefits

Direct compilation to machine code eliminates the performance overhead typical of interpreted frameworks, delivering rendering performance that matches or exceeds native applications.

Widget Framework

Everything is a Widget

This fundamental principle drives Flutter's architecture: text elements, buttons, layout containers, and even the application root are all widgets. This unified approach creates unprecedented consistency and composability.

- ### Composable Architecture

  Widgets combine to form larger, more complex widgets. Small, focused components can be reused and combined in countless ways, promoting code reusability and maintainability.

- ### Reactive Programming Model

  Widgets automatically rebuild when their data changes, ensuring the UI always reflects the current application state without manual intervention or complex update logic.

This widget-centric approach allows complex UIs to be built from small, reusable pieces, making code more maintainable and enabling rapid UI iteration during development.

Platform Channels

Bridge Architecture

Platform channels provide a robust bridge between Dart code and native platform APIs, enabling Flutter applications to access device-specific functionality whilst maintaining a unified codebase architecture.

Flexibility Advantage

Provides the flexibility to access any native functionality without sacrificing the unified codebase benefits. Custom platform channels can be created for proprietary or specialised device integrations.

Accessible Features

- Camera and photo gallery
- GPS and location services
- Device sensors and hardware
- Push notifications
- Native UI components when needed

Best Practices

Use platform channels judiciously—most common functionality is already abstracted through Flutter plugins, and excessive native integration can compromise cross-platform benefits.

Rendering Pipeline

1. **Build Widget Tree**

   Declarative widget descriptions create a tree structure representing the desired UI state and hierarchy.

2. **Create RenderObjects**

   Widgets instantiate corresponding RenderObjects that handle layout calculations and painting operations.

3. **Layout Calculations**

   Constraint-based layout system determines exact positioning and sizing of all UI elements efficiently.

4. **Paint with Skia**

   High-performance Skia engine renders the final visual representation with hardware acceleration.

5. **Display Frame**

   Composited layers are sent to the display system, achieving smooth 60fps performance.

Understanding this sequence helps diagnose layout and performance issues during development. Each stage is optimised for efficiency, with Flutter only rebuilding components that have actually changed.

Real-World Adoption

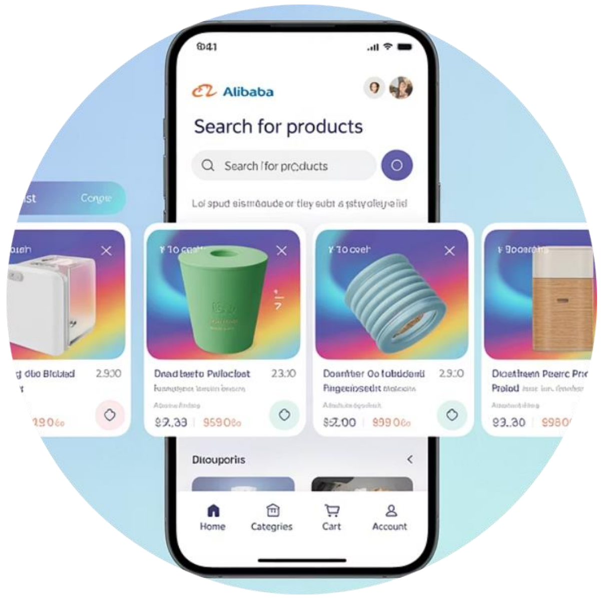
Flutter's enterprise adoption demonstrates its production readiness and scalability. Major companies have chosen Flutter for mission-critical applications, validating its performance and reliability.

Google Ads

Google's own advertising platform leverages Flutter for consistent user experience across mobile platforms, handling millions of daily active users.

BMW

Luxury automotive manufacturer uses Flutter for vehicle companion apps, integrating complex hardware interactions with elegant user interfaces.



Alibaba

E-commerce giant chose Flutter for critical customer-facing applications, demonstrating its capability to handle high-traffic, complex business logic.

eBay Motors

Specialised marketplace application showcases Flutter's ability to handle rich media content and complex user interactions in commercial environments.

Key reasons for adoption: rapid MVP development, consistent UI across platforms, and significantly lower maintenance costs compared to traditional native development approaches.

Activity 2 – Paper & Pen (5 minutes)

What primary advantage of Flutter do you believe best supports your application-development objectives?

Introduction to Dart

Language Characteristics

Dart is a modern, object-oriented, strongly typed programming language specifically designed for client-side development. Its syntax and features make it particularly well-suited for building Flutter applications.

Compilation Flexibility

- **Native machine code** for mobile platforms
- **JavaScript compilation** for web deployment
- **JIT compilation** for development
- **AOT compilation** for production

Learning Curve Advantage

Dart offers a smooth learning curve for developers familiar with Java, C#, JavaScript, or other modern programming languages, reducing the barrier to entry for Flutter development.

Key Design Goals

Optimised for fast development cycles, predictable performance, and easy debugging—making it ideal for both rapid prototyping and production applications.

Dart Type System & Null Safety

Sound Null Safety

Dart's sound null safety system represents a significant advancement in programming language design, preventing null reference errors at both compile time and runtime.

Compile-Time Protection

The compiler catches potential null reference errors before your code runs, eliminating an entire class of runtime crashes that plague many applications.

Runtime Safety

Even in edge cases that escape compile-time analysis, Dart's runtime systems provide additional protection against null pointer exceptions.

Developer Benefits

Safer code leads to fewer production bugs, easier maintenance, and increased developer confidence when refactoring or extending existing codebases.

Professional Impact: Null safety significantly reduces debugging time and production issues, making your applications more reliable and your development process more efficient.

Asynchronous Programming in Dart

The Problem

Network requests, file operations, and database queries can take significant time to complete. If these operations run on the main thread, they block the UI, creating poor user experiences with frozen interfaces and unresponsive controls.

Dart's Solution

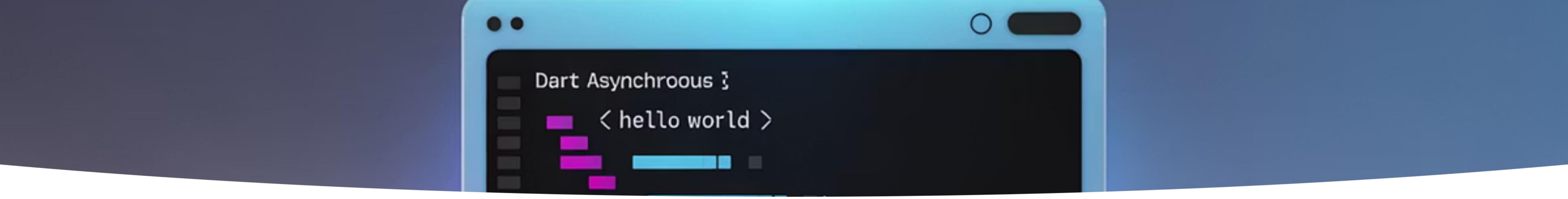
async/await syntax and Futures provide clean, readable non-blocking code that maintains UI responsiveness whilst handling time-consuming operations elegantly.

Streams for Continuous Data

Handle continuous event and data flows like real-time user input, live chat messages, or sensor data using Dart's powerful Stream APIs.

Best Practices

- Use async/await for single operations
- Use Streams for continuous data
- Always handle errors with try-catch
- Avoid blocking the main thread



Dart Example with Async/Await

```
Future<void> main() async {
  final data = await fetchGreeting();
  for (var i = 1; i <= 3; i++) {
    print('$data #$i');
  }
}

Future<String> fetchGreeting() async {
  await Future.delayed(Duration(milliseconds: 300));
  return 'Hello Flutter';
}
```

This example demonstrates several key Dart concepts working together:

- ### Asynchronous Functions
  Functions marked with `async` can use `await` to pause execution until futures complete, without blocking other operations.
- ### Awaiting Results
  The `await` keyword pauses function execution until the future resolves, then continues with the result value.
- ### Simple Loops
  Standard control flow works naturally with asynchronous code, making complex operations easy to read and maintain.

Packages & pub.dev

Official Repository

pub.dev serves as the official package repository for Dart and Flutter, hosting thousands of well-maintained packages that extend your application capabilities significantly.

Selection Best Practices

Choose reputable packages by evaluating maintenance frequency, community support, documentation quality, and compatibility with your Flutter version.

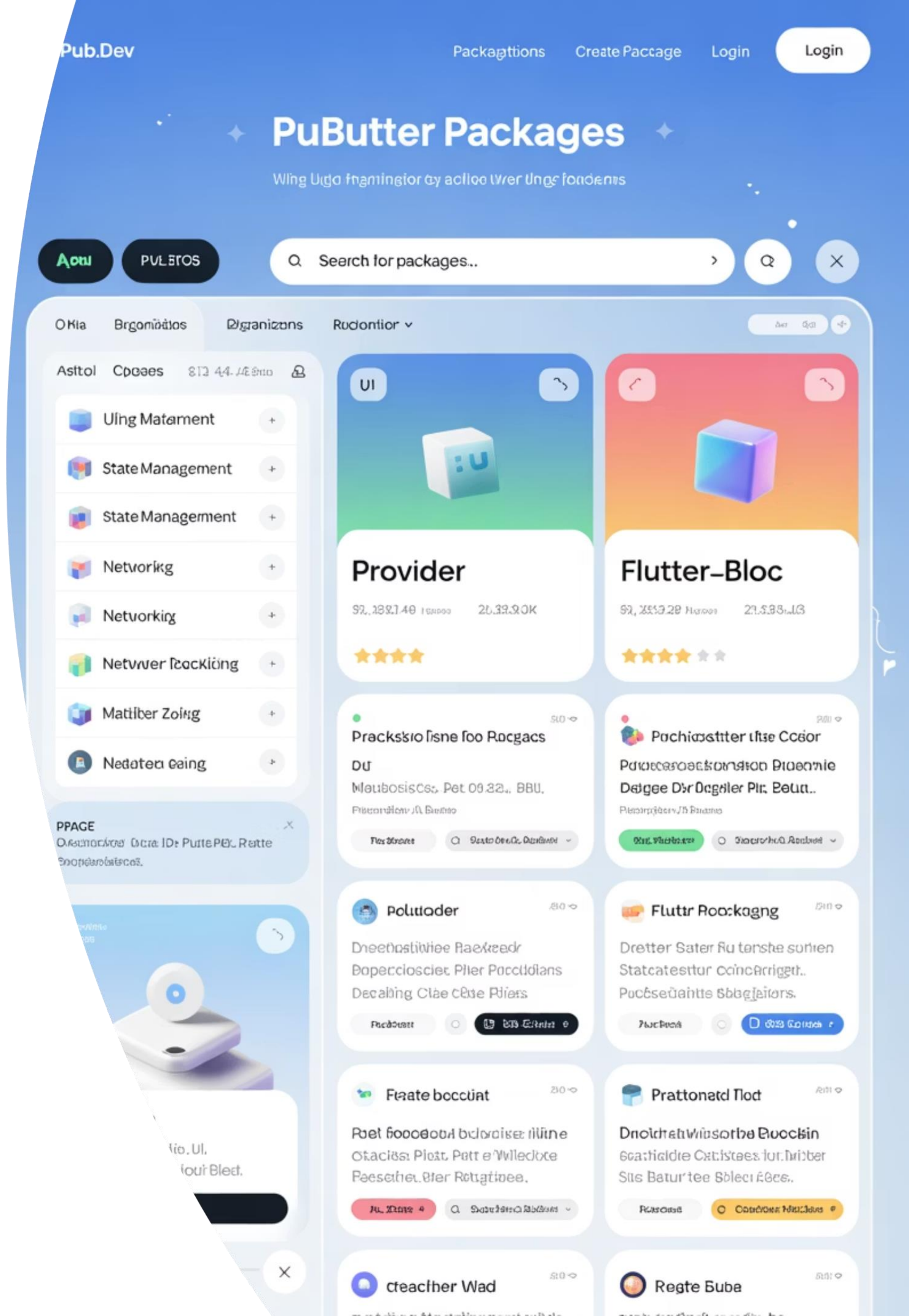
Essential Categories

- HTTP and networking
- JSON parsing and serialisation
- Firebase integration
- SQLite and database access
- State management solutions
- UI components and animations

Evaluation Criteria

1. Recent updates and active maintenance
2. Strong community ratings and usage
3. Comprehensive documentation
4. Compatible license terms
5. Performance impact assessment

Quality packages can dramatically accelerate development whilst maintaining code reliability. However, evaluate dependencies carefully to avoid technical debt and security vulnerabilities.



Activity 3 – Paper & Pen (5 minutes)

"What is the single most important reason you would choose Flutter for a project?"

Required Tools Overview

A proper development environment is crucial for productive Flutter development. These tools work together to provide comprehensive development, testing, and deployment capabilities.

Flutter SDK

Core toolkit and command-line interface providing compilation, hot reload, testing frameworks, and deployment tools for all supported platforms.

Development IDEs

Android Studio (full-featured with excellent debugging) or Visual Studio Code (lightweight with great extensions) both offer strong Flutter support.

Testing Devices

Android Emulator, iOS Simulator, or physical devices for comprehensive testing across different screen sizes and operating system versions.

Version Control

Git recommended for team collaboration, code backup, and project history management—essential for professional development workflows.

Installing Flutter SDK

Download Latest Release

Visit https://flutter.dev and download the latest stable release for your operating system. Stable releases ensure compatibility and reliability.

Extract and Configure Path

Extract the SDK to a secure directory (avoid spaces in path names) and add the flutter/bin directory to your system's PATH environment variable.

Verify Installation

Run `flutter doctor` to check all dependencies and system configuration. This diagnostic tool identifies missing components and configuration issues.

Resolve Dependencies

Address any issues identified by flutter doctor before creating your first project. Common requirements include Android SDK, Xcode (for iOS), and IDE plugins.

Important: Proper PATH configuration ensures Flutter commands work from any directory. Test by opening a new terminal and running `flutter --version`.

Configuring Android Studio

Essential Plugins

Install both **Flutter** and **Dart** plugins from the Android Studio Marketplace. These plugins provide syntax highlighting, debugging support, hot reload integration, and widget inspection tools.

Android Emulator Setup

Configure an Android Virtual Device (AVD) using a modern Pixel device profile. Choose system images with Google Play Services for comprehensive testing capabilities.

SDK License Acceptance

Accept all Android SDK licenses by running `flutter doctor --android-licenses` in your terminal. This step is required for building and deploying Android applications.

Performance Optimisation

- Enable hardware acceleration for emulator
- Allocate sufficient RAM (minimum 4GB)
- Enable Intel HAXM or AMD hypervisor
- Close unnecessary applications during development

Setting Up VS Code (Optional)

Lightweight Alternative

Visual Studio Code offers a lightweight yet powerful alternative to Android Studio, particularly suitable for developers preferring minimal resource usage or those with lower-specification development machines.

Essential Extensions

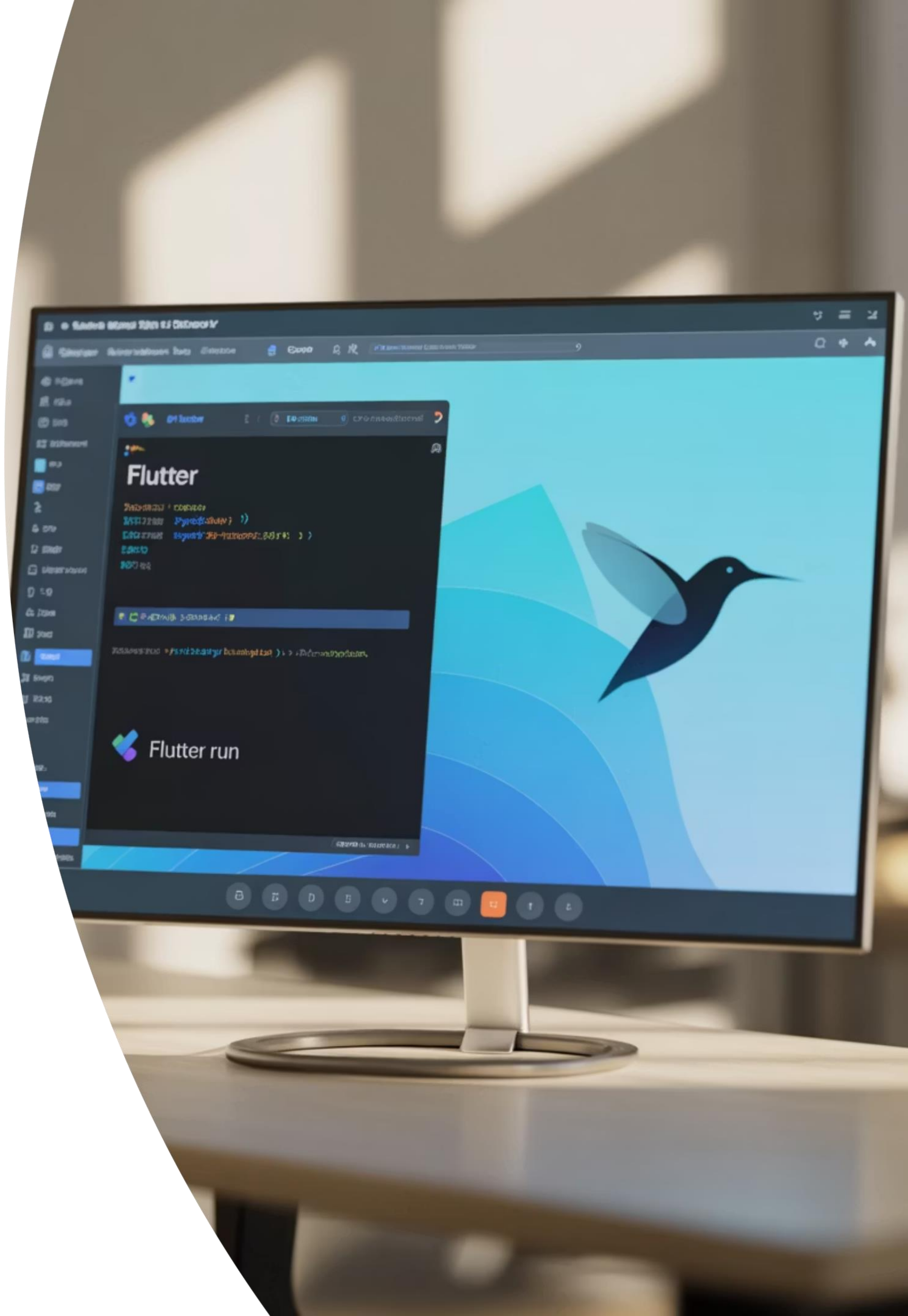
- **Flutter** extension (official)
- **Dart** extension (official)
- **Flutter Widget Snippets** (helpful)
- **Bracket Pair Colorizer** (readability)

Integrated Development

Use the integrated terminal for Flutter commands, ensuring seamless workflow between code editing and command-line operations without switching applications.

When to Choose VS Code

- Limited system resources
- Preference for customisable interface
- Focus on code editing over visual design
- Integration with existing VS Code workflows



Verifying the Installation

flutter doctor

The flutter doctor command serves as your installation health check, providing comprehensive diagnosis of your development environment and highlighting any configuration issues that need resolution.

Comprehensive System Check

Confirms Flutter and Dart versions, detects connected devices, validates IDE plugins, and verifies Android SDK configuration in a single command.

Issue Resolution

Address any warnings carefully—they often indicate missing dependencies or configuration problems that will cause issues during development.

Common Installation Issues

Missing Android SDK components, incorrect PATH variables, outdated Java or Gradle versions, and missing IDE plugins are typical problems with clear solutions.

Pro Tip: Run flutter doctor regularly, especially after system updates or when encountering build issues. It often reveals the root cause of development problems.

Activity 4 – Raise-Hand Discussion

"Can Flutter apps match the performance of native apps? Why or why not?"

Creating the First Project

flutter create my_app

This single command creates a complete, runnable Flutter application with organized folder structure, essential dependencies, and a functional counter app that demonstrates core Flutter concepts.

Generated Project Structure

Creates comprehensive folder hierarchy including source code directories, platform-specific configurations, testing frameworks, and documentation templates.

Entry Point

lib/main.dart serves as your application's entry point, containing the initial widget tree and demonstrating fundamental Flutter development patterns.

Ready-to-Run Application

The generated counter app provides a working example showcasing state management, user interaction, and UI updates—perfect for exploring Flutter's reactive programming model.

Project Structure Explained

Directory/File	Purpose & Contents
`lib/`	Main Dart source code, including main.dart entry point and all application logic
`pubspec.yaml`	Project configuration: dependencies, assets, fonts, and Flutter SDK version constraints
`android/` & `ios/`	Platform-specific configurations, native code integration, and build settings
`test/`	Unit tests, widget tests, and integration tests ensuring code quality and reliability
`web/` & `windows/`	Web and desktop platform configurations for multi-platform deployment

Professional Tip: Organise files by feature rather than by type for scalability. Create directories like `lib/features/auth/` instead of `lib/widgets/` as your project grows.

Running the App & Hot Reload

01

Start Emulator or Connect Device

Launch your Android emulator, iOS simulator, or connect a physical device via USB with developer options enabled for testing.

02

Launch Application

Run `flutter run` in your project directory to compile and launch the default counter application, which demonstrates basic Flutter functionality.

03

Experience Hot Reload

Edit `main.dart` (try changing the app title or primary color) and press 'r' in the terminal or save your file to see changes instantly without losing application state.

Hot Reload Benefits: This feature dramatically accelerates development by preserving application state whilst updating the UI, allowing rapid iteration and immediate feedback during the development process.

Hot reload works for UI changes and most code modifications. For structural changes like adding new dependencies, use hot restart ('R') or stop and restart the application.

Common Setup Pitfalls

Slow Emulator Performance

Enable hardware acceleration in BIOS settings, allocate more RAM to the emulator, close memory-intensive background applications, and consider using a physical device for better performance.

PATH Configuration Issues

Verify correct PATH setup with `echo $PATH` (macOS/Linux) or `where flutter` (Windows). Restart terminal after making PATH changes to ensure they take effect.

Version Conflicts

Stick to the stable Flutter channel unless specific beta features are required. Use `flutter channel stable` and `flutter upgrade` to ensure compatibility.

Prevention Strategy: Follow installation instructions precisely, run `flutter doctor` frequently, and address warnings promptly rather than ignoring them. Most setup issues have well-documented solutions in the Flutter documentation.

Conclusion

Cross-Platform Excellence

Flutter delivers **fast, high-performance cross-platform development** from a single codebase, revolutionising traditional mobile development approaches and significantly reducing time-to-market for applications.

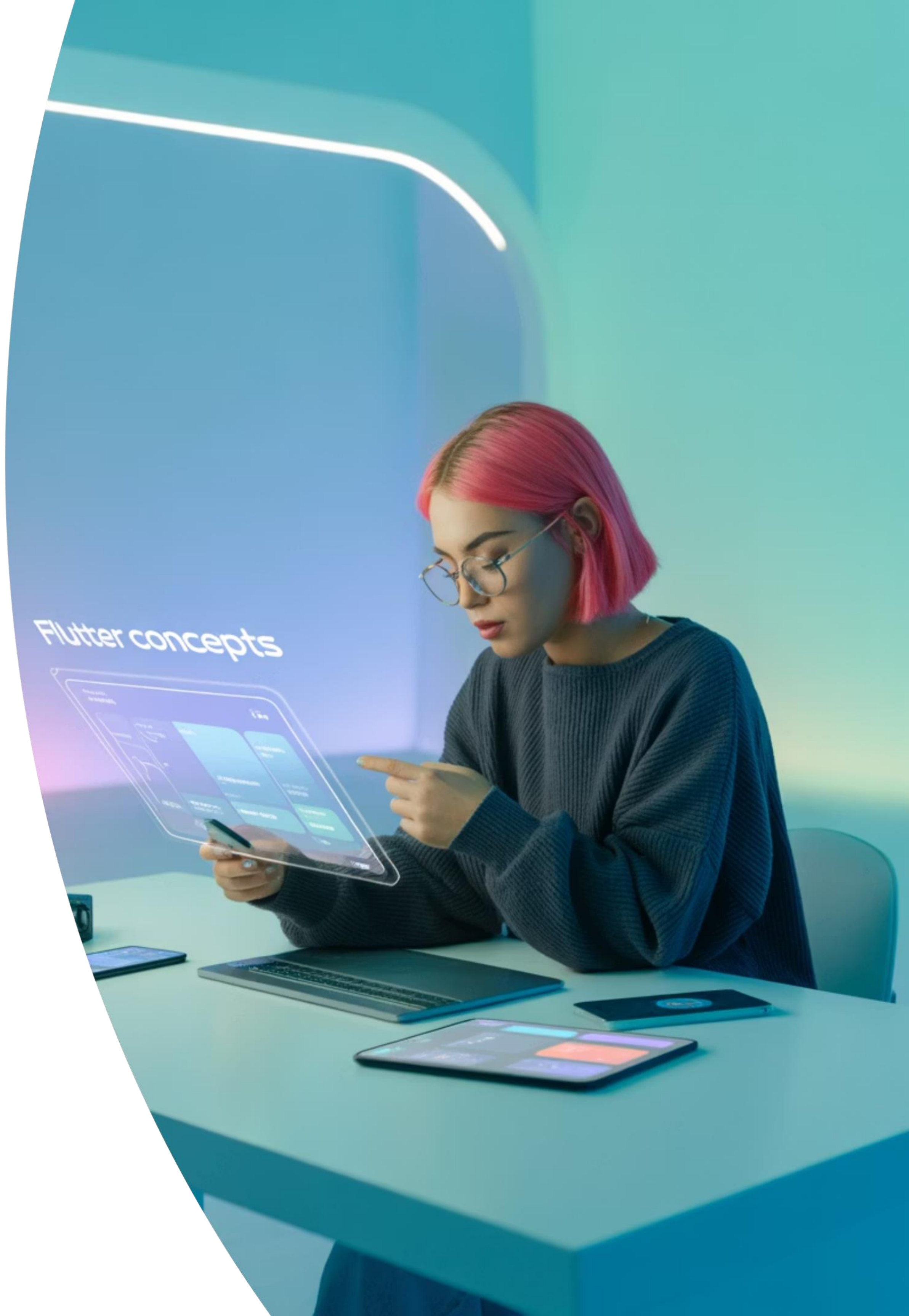
Modern Language Benefits

Dart provides **modern, safe, and efficient** programming features including null safety, asynchronous programming, and strong typing that enhance code reliability and developer productivity.

Foundation for Success

Correct environment setup is crucial for upcoming labs and projects. A properly configured development environment enables smooth learning progression and professional development practices.

These foundational concepts form the basis for everything we'll explore in subsequent lectures. Understanding cross-platform development principles, Flutter's architecture, and Dart's capabilities prepares you for hands-on development work and professional software engineering practices.



Thank you…

Any questions??

My google site

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