Embedded Systems Syllabus

Module	Syllabus
Module 1	**Embedded C & ARM Cortex Programming**
1.1	C Fundamentals – Storage Classes, Data Types, Control Flow, Arrays, Functions, File Operations
1.2	Advanced C – Pointers, Pointer Arithmetic, Pointer to Functions, Structures, Unions, Data Structures (LL, Stack, Queue)
1.3	Embedded C Concepts – Bitwise Operations, Typecasting, Conditional Compilation, Preprocessor
1.4	Embedded Systems Overview – Architecture, Categories, Characteristics, Application Areas
1.5	ARM Cortex Architecture – Registers, Instruction Set, Modes, Memory Hierarchy, ARM vs Thumb, Pipeline Concepts
1.6	Cortex-M4 Peripherals – GPIO, RCC, UART, Timers, ADC, PWM, NVIC Interrupts, Peripheral Registers
1.7	Firmware Build Systems and DFU – Make/CMake, GDB, Flashing, OpenOCD
Module 2	**Embedded Linux**
2.1	Linux Basics – Shell, File Permissions, vi Editor, User Management
2.2	Embedded Linux Architecture – Kernel/User Space, Process, Memory, IPC, File System
2.3	Cross Compilation – Toolchains, Buildroot, Sysroot
2.4	Kernel Compilation – U-Boot, Kernel Config, Driver Integration
2.5	Filesystem and Porting – RootFS Types, Boot Sequence, Flashing
2.6	Raspberry Pi – Setup, OS Installation, Peripheral Interfacing
2.7	Custom Linux Image – Device Tree, RootFS, Kernel Patching
Module 3	**Embedded RTOS**
3.1	RTOS Basics – Real-Time Constraints, Kernel, Scheduling
3.2	Task Management – Context Switching, Delays, Priorities
3.3	Synchronization – Semaphores, Mutexes, Event Flags, Queues
3.4	Memory – Static/Dynamic Allocation, Stack Management

3.5	Debugging – Trace Tools, SystemView, GDB
Module 4	**IoT & Data Analytics**
4.1	IoT Concepts – Sensors/Actuators, Protocols, Stack, Architecture
4.2	Platforms – Arduino, ESP32, NodeMCU, Raspberry Pi
4.3	Communication – MQTT, CoAP, HTTP, BLE, Zigbee, LoRa
4.4	Data Logging – Firebase, Remote/Local Databases
4.5	Python for IoT – Data Collection, Matplotlib, Pandas, NumPy
4.6	Analytics – Regression, Clustering, Classification, ML (Intro)
Module 5	**Protocols & Device Drivers**
5.1	Serial Protocols – UART, SPI, I2C, CAN
5.2	USB Protocol – Device Classes, Endpoints, Transfers
5.3	Linux Device Drivers – Char Drivers, Major/Minor, Registration
5.4	Advanced Drivers – Interrupts, Block, Network
Module 6	**Firmware Security & Hacking**
6.1	Firmware Analysis – Extraction, Disassembly
6.2	Patching – Binary Modification, Behavior Injection
6.3	Secure Boot – Encryption, Auth Mechanisms
Module 7	**TCP/IP and Networking**
7.1	TCP/IP – Stack Layers, Headers, Protocols
7.2	Network Manipulation – Packet Crafting, Encapsulation, VPN Basics
Module 8	**Capstone Project**
8.1	Project Planning – Requirements, Architecture
8.2	Implementation – Board Bring-up, Testing
8.3	Presentation – Report, Demo, Peer Review