Embedded System Course Content

1. Introduction to Embedded Systems

- Definition and characteristics
- Differences between embedded systems and general-purpose computers
- Examples of embedded systems (e.g., home appliances, automotive control systems)
- Applications in various industries (automotive, healthcare, consumer electronics)

2. Embedded System Architecture

- Hardware components (microcontroller, processor, memory, peripherals)
- Software components (embedded software, real-time operating systems)
- Embedded system models (Harvard and Von Neumann architectures)
- System design constraints (cost, power, performance, size)

3. Microcontrollers and Microprocessors

- Differences between microcontrollers and microprocessors
- Common microcontrollers (e.g., ARM, AVR, PIC)
- Architecture of microcontrollers (CPU, memory, I/O ports, timers)
- Programming and interfacing microcontrollers with external devices

4. Embedded System Programming

- Low-level programming (Assembly language)
- High-level programming (C/C++)
- Embedded development tools (compilers, debuggers, IDEs)
- Firmware development and debugging techniques
- Embedded C programming concepts (registers, interrupts, timers)

5. Real-Time Operating Systems (RTOS)

- Basics of RTOS (tasks, scheduling, multitasking)
- Task synchronization and communication (semaphores, message queues)
- RTOS vs. General-purpose operating systems
- Examples of RTOS (FreeRTOS, VxWorks)

6. Interfacing with External Devices

- Sensors and actuators (types and interfacing)
- Communication protocols (SPI, I2C, UART, CAN)
- ADC (Analog to Digital Converter) and DAC (Digital to Analog Converter)
- GPIO (General Purpose Input/Output) and its applications

7. Embedded Communication Protocols

- Serial communication (UART, SPI, I2C)
- Wireless communication (Bluetooth, Zigbee, Wi-Fi)
- CAN and LIN bus in automotive systems
- Ethernet for embedded systems

8. Power Management in Embedded Systems

- Power consumption considerations in embedded devices
- Sleep modes and low-power design techniques
- Battery management and energy harvesting
- Power optimization techniques (hardware and software)

9. Sensors and Actuators in Embedded Systems

- Types of sensors (temperature, humidity, pressure, proximity)
- Interfacing sensors to microcontrollers
- Actuators (motors, relays, solenoids) and their control

10. Embedded System Design

- Embedded system design methodologies
- Hardware-software co-design
- System specification and requirement analysis
- Testing and debugging embedded systems

11. Embedded Systems Security

- Security challenges in embedded systems
- Secure boot, authentication, encryption techniques
- Countering threats (hacking, tampering, malware)

12. Embedded System Case Studies and Applications

- Case studies of specific embedded system applications
- Embedded system design in automotive, healthcare, IoT devices
- Industrial automation and smart home technologies