Syllabus for Real-Time Operating Systems

PG-DESD March 2024
Duration: 60 hours (20 theory hours + 40 lab hours)
Objective: To introduce students to real-time operating system concepts, principles, and development techniques for real-time embedded systems.
Prerequisites: Basic knowledge of operating systems and embedded systems.
Evaluation: 100 Marks (Theory exam – 40%, Lab exam – 40%, Internals – 20%)

Textbook:

- Real-Time concepts for Embedded Systems, Qing Li, Caroline Yao, CMP Media LLC

  or

- Real-Time Systems Design and Analysis: Tools for the Practitioner, 4th Edition, Philipp A.Laplante, Seppo J. Ovaska, Wiley Publisher

References:

- Real-Time Embedded Systems: Design Principles and Engineering Practices, Xiaocong Fan
- The FreeRTOS Reference Manual, FreeRTOS online
- Use of FreeRTOS in Teaching Real-time Embedded Systems Design Course, Dr. NannanHe, Minnesota State University, Mankato
- RTOS Program Models Used in Embedded Systems, József Kopják, Dr. János Kovác**s**

(Note: Each Lecture is of 2 hours and Lab Session is of 4 hours)

Session 1: Introduction to Real-Time Systems

Lecture:

- What are Real-Time Systems?
- Characteristics of Real-Time Systems: Timing Constraints, Determinism, Predictability
- Types of Real-Time Systems: Hard Real-Time, Soft Real-Time
- Challenges in Real-Time System Design

Lab:

- Setting up Development Environment for Real-Time System Development
- Introduction to Real-Time Kernel Development Tools and APIs

Session 2,3: Real-Time Operating System Architecture

Lecture:

- Overview of Real-Time Operating System (RTOS) Components
- Task Management: Task States, Task Scheduling, Context Switching
- Inter-Task Communication and Synchronization
- Memory Management and Resource Allocation

Lab:

- Exploring Task Management and Scheduling in Real-Time Kernels
- Implementing Inter-Task Communication Mechanisms

Session 4,5: Real-Time System Design Considerations

Lecture:

- Task Partitioning and Priority Assignment
- Deadline Analysis and Task Timing Requirements
- Resource Management and Allocation
- Fault Tolerance and Error Handling

Lab:

- Designing and Implementing Real-Time Systems with Task Partitioning and Priority Assignment
- Analyzing Task Timing Requirements and Resource Allocation

Session 6,7: Task Scheduling Algorithms

Lecture:

- Preemptive vs Non-Preemptive Scheduling
- Scheduling Policies: Rate Monotonic (RM), Earliest Deadline First (EDF), Fixed Priority, Dynamic Priority
- Analysis of Scheduling Algorithms: Response Time Analysis, Worst-Case Execution Time (WCET)

Lab:

- Implementing Various Task Scheduling Algorithms in Real-Time Systems
- Analyzing Scheduling Results and Performance Metrics

Session 8,9: Interrupt Handling in Real-Time Systems

Lecture:

- Introduction to Interrupts in Real-Time Systems
- Priority-Based Interrupt Handling
- Interrupt Latency and Response Time Analysis
- Interrupt Service Routines (ISRs) and Deferred Interrupt Handling

Lab:

- Configuring and Handling Interrupts in Real-Time Systems
- Analyzing Interrupt Latency and Response Time

Session 10: Inter-Process Communication (IPC)

Lecture:

- Message Passing: Queues
- Shared Memory and Memory-Mapped I/O
- Semaphores, Mutexes, and Critical Sections

Lab:

- Implementing Message Passing Mechanisms for Inter-Process Communication
- Exploring Shared Memory and Synchronization Techniques