GANPAT UNIVERSITY									
FACULTY OF ENGINEERING & TECHNOLOGY									
Programme	Master of Technology					Branch/Spec.	Electronics and Communication Engineering – Embedded Systems		
Semester	II					Version	1.0.0.0		
Effective from Academic Year			2026-27			Effective for the Batch admitted in			July 2026
Course Code	3ES2101		Course Name			Real-Time Operating Systems (RTOS)			
Teaching Scheme						Examination Scheme (Marks)			
(Per week)	Lecture(DT)		Practical(Lab.)		Total		CE	SEE	Total
	L	TU	P	TW					
Credit	3	0	1	-	4	Theory	50	50	100
Hours	3	0	2	-	5	Practical	25	25	50

Pre-requisites

Fundamentals of Embedded Systems, C Programming, Microcontroller Architecture, Computer Organization, and Basic Operating System Concepts.

Course Outcomes

On successful completion of the course, the students will be able to:

CO1	Understand real-time operating system fundamentals, scheduling techniques, synchronization, and task management concepts used in embedded systems.
CO2	Develop multitasking embedded applications using RTOS services such as semaphores, message queues, timers, and inter-task communication mechanisms.
CO3	Design and implement real-time embedded applications using FreeRTOS with debugging, optimization, and performance analysis techniques.
CO4	Design, implement, and debug deterministic multitasking firmware by effectively utilizing RTOS primitives, such as task scheduling, semaphores, mutexes, message queues, and software timers.

Theory Syllabus

Unit	Content	Hrs.
1	**Introduction to RTOS:** Introduction to Operating Systems, Real-Time Constraints and Deadlines, Characteristics of Real-Time Embedded Systems, Hard Real-Time Systems, Soft Real-Time Systems, Firm Real-Time System, Deterministic System Behaviour, Latency and Response Time Concepts, RTOS vs General Purpose Operating Systems (GPOS), Architecture of RTOS, RTOS Kernel Components, Monolithic and Microkernel Architectures, Pre-emptive and Cooperative Scheduling, Context Switching Mechanism.	8
2	**Task Management & Scheduling:** Task and Process Concepts, Task Control Block (TCB), Task Life Cycle and Task States, Task Creation and Deletion, Task Suspension and Resumption, Idle Task and Background Processing, Context Switching and CPU Scheduling, Scheduling Policies in RTOS, Priority-Based Scheduling, Round Robin Scheduling, Cooperative Scheduling, Rate Monotonic Scheduling (RMS), Earliest Deadline First (EDF) Scheduling.	8
3	**Synchronization Mechanisms:** Need for Synchronization in RTOS, Shared Resource Management, Critical Section Problem, Race Conditions and Deadlocks, Binary Semaphores, Counting Semaphores, Mutex Mechanisms, Recursive Mutex Concepts, Priority Inversion Problem, Priority Inheritance Protocol, Priority Ceiling Protocol, Problem Event Flags and Event Groups	9
4	**Inter-Task Communication**: Fundamentals of Inter-Task Communication (ITC), Data Sharing in RTOS, Message Queue Architecture, Queue Operations and Management, Mailboxes and Message Passing, Pipes and Stream Communication, Shared Memory Concepts, Producer-Consumer Model, Timers and Software Timers, Clock Management in RTOS, Real-Time Clock (RTC) Concepts, Timeout Handling Mechanisms.	10
5	**FreeRTOS Implementation:** Introduction to FreeRTOS Architecture, FreeRTOS Kernel Components, FreeRTOS Directory Structure, FreeRTOS Porting Concepts, Porting FreeRTOS to ARM Cortex Controllers, Task Creation APIs in FreeRTOS, Queue and Semaphore APIs, Timer APIs	10

	and Event Handling, Interrupt Management in FreeRTOS, Memory Management Schemes in FreeRTOS.	
Practical Content		
Practical, assignments and tutorials are based on above syllabus.		
Text Books		
1	Richard Barry – Mastering the FreeRTOS Real-Time Kernel, Real-Time Engineers Ltd.	
Reference Books		
1	Qing Li & Caroline Yao – Real-Time Concepts for Embedded Systems, CMP Books.	
ICT/MOOCs Reference		
1	https://www.youtube.com/watch?v=dHsHP9RrXBw&list=PLJ5C_6qdAvBH-JNRIlupFb44miyx9M8JD	
2	https://www.youtube.com/watch?v=n1P9scxS1uc&list=PLJ5C_6qdAvBH-JNRIlupFb44miyx9M8JD&index=4	

Mapping of CO with PO and PSO :

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	3	3	3	2	3	2	2	2	3	1	1	1	2
CO2	2	2	2	2	2	3	2	3	3	3	2	2	2	2	1
CO3	3	3	3	3	3	2	2	3	3	2	2	1	1	1	2
CO4	3	1	3	3	2	2	3	1	3	2	2	3	3	3	2