COURSEPACK (Winter 2025-26)

SCHEME

The scheme is an overview of work-integrated learning opportunities and gets students out into the real world. This will show what a course entails.

<table>
<tr><td>Course Title</td><td colspan="3">Operating System</td><td colspan="4">Course Type</td><td colspan="2">Integrated</td></tr>
<tr><td>Course Code</td><td colspan="3">R1UC403B</td><td colspan="4">Class</td><td colspan="2">B. Tech CSE 4th Sem</td></tr>
<tr><td rowspan="6">Instruction delivery</td><td>Activity</td><td>Credits</td><td>Credit Hours</td><td colspan="4" rowspan="2">Total Number of Classes per Semester</td><td colspan="2" rowspan="2">Assessment in Weightage</td></tr>
<tr><td>Lecture</td><td>3</td><td>3</td></tr>
<tr><td>Tutorial</td><td>0</td><td>0</td><td rowspan="3">Theory</td><td rowspan="3">Tutorial</td><td rowspan="3">Practical</td><td rowspan="3">Self-study</td><td rowspan="3">CIE</td><td rowspan="3">SEE</td></tr>
<tr><td>Practical</td><td>1</td><td>2</td></tr>
<tr><td>Self-study</td><td>0</td><td>1</td></tr>
<tr><td>Total</td><td>4</td><td>6</td><td>40</td><td>0</td><td>24</td><td>15</td><td>50%</td><td>50%</td></tr>
<tr><td>Course Lead</td><td colspan="2">Mr. Arunendra Mani Tripathi</td><td>Course Coordinator</td><td colspan="6">Dr. Riman Mandal</td></tr>
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COURSE OVERVIEW

This course will introduce the student to the basic concepts involved in the design and implementation of an operating system. Students will be made familiar to the important modules of operating systems like process management, memory management, file systems, synchronization primitives and exception handling. Important data structures used in the design of these modules will be introduced. The accompanying lab course is intended to give students an illustration of the concepts introduced in the theory course.

PREREQUISITE COURSE

PREREQUISITE COURSE REQUIRED	YES	
If, yes please fill in the Details.	**Prerequisite course code**	**Prerequisite course name**
		Computer Organization Architecture.

COURSE OBJECTIVE

- To explain the functions, services, and structure of operating systems.
- To analyze processes, threads, and CPU scheduling techniques.
- To apply process synchronization concepts and evaluate deadlock handling methods.
- To demonstrate memory management and virtual memory mechanisms.
- To utilize file system concepts, secondary storage management, and disk scheduling methods.

COURSE OUTCOMES(COs)

After the completion of the course, the student will be able to:

CO No.	Course Outcomes
R1UC403B .1	Describe at least five core functions and structural components of an operating system.
R1UC403B .2	Analyze process management and compare six CPU scheduling algorithms based on performance criteria.
R1UC403B .3	Apply synchronization techniques and solve deadlock-related problems using appropriate algorithms.
R1UC403B .4	Explain memory management, file systems, and disk scheduling techniques.

BLOOM'S LEVEL OF THE COURSE OUTCOMES

Bloom's taxonomy is a set of hierarchical models used for the classification of educational learning Objectives into levels of complexity and specificity. The learning domains are cognitive, affective, and psychomotor.

COMPREHENSIVE

CO No.	Remember **KL1**	Understand **KL 2**	Apply **KL 3**	Analyse **KL 4**	Evaluate **KL 5**	Create **KL 6**
R1UC403B .1		√				
R1UC403B .2			√			
R1UC403B .3			√			
R1UC403B .4				√		

PROGRAM OUTCOMES (POs): AS DEFINED BY CONCERNED THE APEX BODIES

PO1:	**Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
PO2:	**Problem Analysis:** Identify, formulate, review research literature and analyse complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4).
PO3:	**Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5).
PO4:	**Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).
PO5:	**Modern Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6).
PO6:	**The Engineer and The World:** Analyse and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7:	**Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9).
PO8:	**Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9:	**Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

PO10:	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments..
PO11:	**Life-Long Learning:** Recognize the need for, and have the preparation and ability for: i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8).
PSO1:	Have the ability to work with emerging technologies in Computer Science and Engineering requisite to Industry 4.0.
PSO2:	Demonstrate Engineering Practice learned through industry internship and research project to solve live problems in various domains.

COURSE ARTICULATIONMATRIX

The Course articulation matrix indicates the correlation between Course Outcomes and Program Outcomes and their expected strength of mapping in three levels (low, medium, and high).

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
R1UC403B .1	2	-	-	-	-	-	-	-	-	-	-	-	2	-
R1UC403B .2	2	1		-	-	-	-	-	-	-	-	-	-	2
R1UC403B .3	2	2	-	-	-	-	-	-	-	-	-	-	2	-
R1UC403B .4	2	2	-	-	-	-	-	-	-	-	-	-	-	2

Note: 1-Low, 2-Medium, 3-High

COURSE ASSESSMENT

The course assessment patterns are the assessment tools used both in formative and summative examinations.

Assessment Pattern for Integrated (Blended) Course:

	CIE			Total Marks		
Type of Course (B)	LAB Work@ + Record	MTE	LAB EXAM*	CIE	SEE	**Final Marks CIE*0.5+SEE*0.5**
INTEGRATED	25	50	25	100	100	100

@ Lab Work – 15 marks + Lab record – 10 marks

* Passing criteria – 30% of marks to be secured in the lab exam conducted by two examiners (one internal + one external).

COURSE CONTENT
THEORY+ PRACTICAL

Contents
Theory Introduction: Operating system and functions, Classification of Operating systems-Batch, Interactive, Time sharing, Real Time System, Multiprocessor Systems, Multiuser Systems, Multi process Systems, Multithreaded Systems, Operating System Structure-Layered structure, System Components, Operating System services. CPU Scheduling: Scheduling Concepts, Performance Criteria, Process Concept Process States, Process Transition Diagram, Schedulers, Process Control Block (PCB), Process address space, Process identification information, Threads and their management, Scheduling Algorithms, Multiprocessor Scheduling. Concurrent Processes: Process Concept, Principle of Concurrency, Producer / Consumer Problem, Mutual Exclusion, Critical Section Problem, Peterson's solution, Semaphores, Test and Set operation; Classical Problem in Concurrency-Dining Philosopher Problem; Inter Process Communication models and Schemes, Process generation. Deadlock: System model, Deadlock characterization, Prevention, Avoidance and detection, Recovery from deadlock. Memory Management: Basic bare machine, Resident monitor, Multiprogramming with fixed partitions, Multiprogramming with variable partitions, Protection schemes, Paging, Segmentation, Paged segmentation, Virtual memory concepts, Demand paging, Performance of demand paging, Page replacement algorithms, Cache memory organization, Locality of reference. I/O Management and Disk Scheduling: I/O devices, and I/O subsystems, I/O buffering, Disk storage and disk scheduling. File System: File concept, File organization and access mechanism, File directories, and file sharing, File system implementation issues, File system protection and security.

Lab (To be implemented in C)

Lec.No	Points To Covered
1	Basic Commands and programs based on C and in Linux Operating System
2	Write programs using the following system calls of LINUX operating system: fork, exec, wait
3	Write a C program using the following system calls (get_pid, exit).
4	Write a C program to simulate CPU scheduling algorithms: FCFS
5	Write a C program to simulate CPU scheduling algorithms: SJF
6	Implementation Round Robin Algorithm in C
7	Implement the Dining Philosopher problem using semaphores
8	Implement the Producer – Consumer problem using semaphores
9	Write a C program to simulate Bankers Algorithm for Deadlock Detection
10	Write a C programs to simulate Page Replacement Algorithms a) FIFO b) LRU
11	Implementation of memory allocation algorithms: a) First Fit b) Best Fit c) Worst Fit)
12	Write a C programs to simulate implementation of FCFS, SSTF Disk Scheduling Algorithms.

LESSON PLAN

L.No.	Topics for Delivery	Theory/Practical	Skills	Competency	CO Mapping
1	Introduction: Operating system and functions	Theory	Concept identification	Explain OS roles and functions	CO1
2	OS services, system components		System analysis	Describe OS services and components	
3	Classification of operating systems		Comparative analysis	Differentiate types of OS	

4	Layered OS structure		Structural understanding	Explain OS architecture models	
5	Process concept, process generation		Process modeling	Describe process lifecycle	
6	Inter-process communication (IPC)		Communication mechanism analysis	Explain IPC methods	
7	PCB, process states, transition diagram		State analysis	Interpret process state transitions	
8	Schedulers		Scheduler identification	Explain types of schedulers	
9	CPU scheduling concepts and criteria		Performance evaluation	Analyze scheduling criteria	
10	FCFS scheduling		Algorithm tracing	Apply FCFS scheduling	CO2
11	SJF scheduling		Algorithm comparison	Compare SJF with FCFS	
12	SRTF scheduling		Preemptive scheduling analysis	Solve SRTF problems	
13	Priority scheduling		Algorithm evaluation	Apply priority scheduling	
14	Round Robin, multilevel queue		Time-sharing analysis	Evaluate RR and multilevel scheduling	
15	Threads and management		Thread modeling	Explain thread operations	
16	Mutual exclusion, critical section		Concurrency reasoning	Analyze critical section problems	
17	Peterson’s solution		Algorithm understanding	Explain Peterson’s algorithm	
18	Semaphores, test-and-set		Synchronization design	Apply semaphore operations	
19	Dining philosopher, producer–consumer		Problem solving	Solve classical synchronization problems	CO3
20	Deadlock system models		Deadlock analysis	Identify deadlock conditions	
21	Deadlock prevention and avoidance		Strategy evaluation	Compare prevention and avoidance	
22	Deadlock recovery		Recovery planning	Apply recovery techniques	
23	Introduction to memory management		Memory concept analysis	Explain memory management functions	CO4

24	Fixed partitioning		Allocation analysis	Apply fixed partition schemes	
25	Variable partitioning		Allocation strategy comparison	Compare partitioning techniques	
26	Virtual memory and thrashing		Performance analysis	Explain virtual memory behavior	
27	First fit, best fit, worst fit		Allocation algorithm solving	Apply memory allocation methods	
28	Paging and segmentation		Address translation	Differentiate paging and segmentation	
29	Page replacement algorithms		Algorithm comparison	Solve page replacement problems	
30	Cache memory organization		Memory hierarchy analysis	Explain cache concepts	
31	I/O devices, subsystems, buffering		I/O mechanism analysis	Describe I/O operations	
32	Disk scheduling: FCFS, SSTF		Disk algorithm solving	Apply disk scheduling methods	
33	Disk scheduling: SCAN, LOOK, C-LOOK		Algorithm comparison	Compare disk scheduling techniques	
34	File concept and organization		File structure analysis	Explain file organization	
35	File directories, access, sharing		File system design	Analyze file access and sharing	
36	Revision		Concept integration	Reinforce OS concepts	
37	Revision		Problem solving	Strengthen algorithmic skills	
38	Revision		Concept clarification	Improve conceptual clarity	CO1–CO4
39	Revision		Application practice	Apply OS techniques	
40	Revision		Comprehensive review	Demonstrate overall competency	

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PROBLEM-BASED LEARNING

Exercises in Problem-based Learning (Assignments)

Sr. No.	Practice Problem
1.	Define an Operating system. Explain the functions of an operating system.
2.	Explain the classification of operating system in detail.
3.	Define batch systems? How they are different from time sharing systems?
4.	Define the benefit of viewing a system such as an operating system as a set of layers?
5.	What are the main differences between operating systems for main frame computers and personal computers?
6.	Classify the following applications as batch-oriented or interactive: a) Word processing b) Generating monthly bank statements Computing pi to a million decimal places
7.	Define a real time system or interactive system. Define its characteristics?

8.	Consider a system with a set of processes P1, P2, P3 and P4. Let their arrival times and CPU burst times mentioned as below:- Process Arrival time CPU Burst Time P1 0 3 P2 1 6 P3 5 4 P4 6 2 1) Draw Gant chart using FCFS, SJF, RR (Assume quantum to be 2 units of time] Calculate: -a) Average Turnaround Time (b) Average Waiting Time
9.	Suppose the following disk request sequence (track numbers) for a disk with 100 tracks is given: 45, 20, 90, 10, 50, 60, 80, 25, 70. Assume that the initial position of the R/W head is on track 50. Compute the additional distance in tracks that will be traversed by the R/W head when the Shortest Seek Time First (SSTF) algorithm and SCAN (Elevator) algorithm are used (assuming that SCAN algorithm moves towards 100 when it starts execution).
10.	Given memory partitions of 100 KB, 500 KB, 200 KB, 300 KB, and 600 KB (in order), how would each off the first fit, best fit, and worst fit algorithms place processes of 212 KB, 417 KB, 112 KB, and 426 KB (in order) ? Which algorithm makes the most efficient use of memory?
11.	On a system using first-fit allocation, assume memory is allocated as below before additional requests for 20K, 10K, 5K are received. Used Hole Used Hole Used Hole Used Hole Used Hole Used Hole 10 K 10K 20K 30K 10K 5K 30K 20K 10K 15K 20K 20K At what starting address will each of the additional requests be allocated?
12.	Explain the following: a) Page Table Base Register b) TLB Miss c) Valid- Invalid bit d) Effective memory access time
13.	Given references to the following pages by program: 0,1,4,2,0,2,6,5,1,2,3,2,1,2,6,2,1,3,6,2how many page faults will occur if the program has three page frames available to it and uses: a) FIFO replacement
	b) LRU replacement c) Optimal replacement
14.	List three examples of deadlocks that are not related to a computer system environment.
15.	Explain the differences between multiprocessor and multi-tasking systems.
16.	Explain the idea/concept behind Multiprogramming? How multi-programming is different from multiprocessing?

17.	Consider the following set of processes that need to be scheduled on a single CPU. All the times are given in milliseconds. Process Name Arrival Time Execution Time A 0 6 B 3 2 c 5 4 D 7 6 E 10 3 Using the *shortest remaining time first* scheduling algorithm, calculate the average process turnaround time (in msec)
18.	Explain the different system components of operating system in detail.
19.	What are the objectives of a good scheduling algorithm?
20.	For the processes, Draw the chart illustrating their execution time: Process Arrival Time Processing time A 0.0000 3 B 1.001 6 C 4.001 4 D 6.001 2 a) Compute the Average turnaround time using Round-robin (quantum=2), Round-robin(quantum=1). b) Compute the wait time using Round-robin (quantum=2), Round-robin(quantum=1).
21.	For the processes, Draw the chart illustrating their execution time: Process Arrival Time Processing time A 0.0000 3 B 1.001 6 C 4.001 4 D 6.001 2 a) Compute the Average turnaround time using FCFS, SJF. b) Compute the wait time using FCFS, SJF.
22.	Define the following: a) Wait time b) Response time c) Turnaround time
23.	Define a critical section? List the requirements that a solution to the critical section problem must satisfy?
24.	Explain the following: (a) Mutual exclusion
	(b) Bounded waiting (c) Race condition
25.	Explain critical section problem in concurrency.
26.	List and describe different types of semaphore? Which semaphore is used to solve Producer consumer problem?
27.	Describe a semaphore? Give difference between a semaphore and mutex.

28.	Explain deadlock and starvation in a semaphore.
29.	Consider a logical address space of 64 pages of 1,024 words each, mapped onto a physical memory of 32 frames. a. How many bits are there in the logical address? b. How many bits are there in the physical address?
30.	Given five memory partitions of 100 KB, 500 KB, 200 KB, 300 KB, and 600 KB (in order), how would the first-fit, best-fit, and worst-fit algorithms place processes of 212 KB, 417 KB, 112 KB, and 426 KB (in order)? Which algorithm makes the most efficient use of memory?
31.	Consider the following page reference string: 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6. How many page faults would occur for the following replacement algorithms, assuming one, two, three, four, five, six, and seven frames? Remember that all frames are initially empty, so your first unique pages will cost one fault each. • LRU replacement • FIFO replacement • Optimal replacement

32.	The following is a code with two threads, producer and consumer, that can run in parallel. Further, S and Q are binary semaphores equipped with the standard P and V operations.
	semaphore S = 1, Q = 0;
	integer x;
	
	producer: consumer:
	while (true) do while (true) do
	P(S); P(Q);
	x = produce (); consume (x);
	V(Q); V(S);
	done done
	
	Which of the following is TRUE about the program above?
	(A) The process can deadlock
	(B) One of the threads can starve
	(C) Some of the items produced by the producer may be lost
	(D) Values generated and stored in ‘x’ by the producer will always be consumed before the producer can generate a new value

33.	Choose among the following suffer from Belady's anomaly and which of them not. Explain. a) LRU replacement b) FIFO replacement c) Optimal replacement
34.	Define page replacement? Define the need of page replacement? Elaborate it via diagram.

35.	Suppose the following disk request sequence (track numbers) for a disk with 100 tracks is given: 45, 20, 90, 10, 50, 60, 80, 25, 70. Assume that the initial position of the R/W head is on track 50. Compute the additional distance in tracks that will be traversed by the R/W head when the Shortest Seek Time First (SSTF) algorithm and SCAN (Elevator) algorithm are used (assuming that SCAN algorithm moves towards 100 when it starts execution).
36.	Write short notes on: a. Devices independent I/O software b. Device Controller c. Interrupt handler d. I/O Devices.
37.	Consider a disk queue with request for input/output to block cylinders 98, 183, 37, 122, 14, 124, 65, 67 in that order. Assume that disk head is initially positioned at cylinder 53 and moving towards cylinder number 0. Compute the total number of head movements using Shortest Seek Time First (SSTF) and SCAN algorithms are respectively
38.	Suppose a disk drive has 400 cylinders, numbered 0 to 399.The driver is currently serving a request at cylinder 143.The queue of pending request in FIFO order is: 86,147,312,91,177,48,309,222,175,130. Starting from the current head position Define the total distance in cylinders that the disk to satisfy all the pending request for each of the following disk scheduling algorithms? 1] SCAN 2] C-SCAN
39.	Define file management system? Define the main tasks of the file management system?

(Course Lead) **(Program Chair)** **(Dean)**