Software Hardware Co-Design

Code: CS32224CS	Course Type: Elective	Semester: II
Evolution Scheme (TA-MSE-ESE): 20-30-100	Total Marks: 150	L-T-P (Credits): 3-0-0 (3)

Pre-Requisites: NIL

Course Objectives:

To understand software-hardware co-design principles and to design, develop, and optimize integrated SoC/FPGA-based systems for real-world AI and data science applications.

Course Outcomes: At the end of the course, the student will be able to

CO-1	Analyze the fundamentals of software-hardware co-design, including design methodologies, specification models, and performance trade-offs.
CO-2	Apply software-hardware partitioning and scheduling techniques for efficient system design.
CO-3	Design and evaluate communication interfaces between hardware and software components using standard protocols and co-simulation methods.
CO-4	Develop and optimize integrated systems using SoC and FPGA-based platforms for real-world applications of AI/DS.

Course Articulation Matrix:

PO	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
CO-1	3	2	1	1	2
CO-2	3	3	2	1	3
CO-3	3	3	2	1	3
CO-4	3	3	2	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit-1: Fundamentals of Hardware–Software Co-Design

Introduction to hardware systems and co-design concepts, Design flow and design methodologies, Specification models (FSM, dataflow, control/data flow graphs), Hardware vs software trade-offs, Performance metrics: latency, throughput, power, cost

Unit-2: SW/HW Partitioning and Scheduling

Software-Hardware partitioning techniques, Granularity of partitioning, Static and dynamic scheduling, Task graphs and scheduling algorithms, Co-synthesis approaches

Unit-3: Communication and Interface Design

Interfacing processors with hardware accelerators, Bus-based communication (AMBA, AXI basics), Memory-mapped I/O and interrupts, Communication protocols and synchronization, Co-simulation and verification techniques

Unit-4: System Integration and Case Studies

System-on-Chip (SoC) design concepts, FPGA-based co-design (e.g., Zynq/PYNQ platforms) for AI/DS applications, Real-time constraints and optimization, Power and performance optimization, Case studies: multimedia, AI accelerators, embedded applications

Learning Resources:

Text Books:

1. Wolf, W. (2012). Computers as Components: Principles of Embedded Computing System Design (3rd ed.). Morgan Kaufmann.
2. Gajski, D. D., Vahid, F., Narayan, S., & Gong, J. (1994). Specification and Design of Embedded Systems. Prentice Hall.

Reference Books:

1. De Micheli, G., & Gupta, R. K. (1997). Hardware/Software Co-Design. Proceedings of the IEEE, 85(3), 349–365.
2. Teich, J. (2012). Hardware/Software Codesign: The Past, the Present, and Predicting the Future. Proceedings of the IEEE, 100(Special Centennial Issue), 1411–1430.