**MANIPAL UNIVERSITY JAIPUR**School of Computing and IT

Department of Computer and Communication Engineering  
Course Hand-out

Digital Design and Computer architecture | CC 2101 | 4 Credits | 3 0 1 4

Session: July 20 – Nov. 20 | Faculty: Dr. Kusum Lata Jain, Dr. Vijay Kumar Sharma | Class: III Semester



1. **Introduction:** This course is offered by Dept. of Computer and Communication Engineering for third semester students. The core objective of this course is to describe the general organization and architecture of a computer system. It covers in detail various functional units of a computer system, machine instructions, addressing techniques and instruction sequencing. It provides a detailed coverage of logic circuits to perform various arithmetic operations and use of pipelining in the design of high-performance processors.
2. **Course Outcomes:** At the end of the course, students will be able to
3. Describe digital components and digital logic circuits for computer system
4. Describe various data representations and analyse the design of fast arithmetic circuits.
5. Formulate assembly language programs for a given high level language construct.
6. Describe various parts of a system memory hierarchy and caching techniques.
7. Evaluate the performance of CPU, memory and I/O operations.
8. Build the required skills to read and research the current literature in computer architecture.
9. **PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES** 
   1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
   2. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
   3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
   4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
   5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations
   6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice
   7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
   8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices
   9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
   10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
   11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
   12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

**Program Specific Outcomes (PSOs)**

At the end of the B Tech CCE program, the student:

**[PSO.1] Clearly imbibe the basic principles, concepts and applications of computer based Communication/networking, information sharing, signal processing, web based systems, smart devices and communication technology.**

**[PSO.2] Investigate problematic areas prevalent in the field of Computer and Communication Engineering to find acceptable solutions.**

**[PSO.3] Identify the existing open problems in the field of computing and propose the best possible solutions.**

**[PSO.4] Apply the contextual knowledge in the field of computing and communication to assess social, health, safety and cultural issues and endure the consequent responsibilities relevant to the professional engineering practice.**

1. **Assessment Plan:**

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| --- | --- | --- | --- |
| **Criteria** | **Description** | **Date** | **Maximum Marks** |
| Internal Assessment (Summative) | Sessional Exam I (Closed Book) | Sept 05 – Sept 09 | 20 |
| Sessional Exam II (Closed Book) | Nov 04 – Nov 06 | 20 |
| Quizzes and Assignments (Accumulated and Averaged) | Regularly | 20 |
| End Term Exam  (Summative) | End Term Exam (Closed Book) | Nov 29 – Dec 13 | 40 |
|  | Total |  | 100 |
| Attendance  (Formative) | A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves. | | |

1. **SYLLABUS**

Digital logic circuits: logic gates, Boolean algebra, map simplification, combinational circuits, flip-flops, sequential circuits; Digital components: Integrated circuits, decoders, multiplexers, registers, shift registers, binary counters; Memory unit: Von-Neumann model for computer/ Von-Neumann architecture, performance; Machine instructions and programs: numbers, arithmetic operations and characters, memory locations and addresses, instructions and instruction sequencing, addressing modes, assembly language, additional instructions, encoding of machine instructions; Arithmetic: addition and subtraction of signed numbers, design of fast adders, multiplication of positive numbers, signed operand multiplication, fast multiplication, integer division, floating point numbers and operations; Introduction to CPU design: instruction interpretation and execution, microoperation and their RTL specification, memory hierarchy, main memory, types and interfacing; Cache Memory: organization and operations, levels of caches; memory management module: paging and segmentation, virtual memory, disk memory, raids, back-up memory; RISC and CISC processors; Introduction to input/output processing: programmed controlled i/o transfer, interrupt controlled I/O transfer, DMA controller; Pipelining and pipeline hazards: design issues of pipeline architecture; Instruction level parallelism and advanced issues: introduction to interconnection network and practical issues.

References:

1. M. M. Mano, Computer System Architecture, (3e), Pearson Education, 2014.

2. C. Hamacher, Z. Vranesic, S. Zaky, Computer Organization, (6e), McGraw Hill, 2011.

3. J. P. Hayes, Computer Architecture and Organization, (3e), McGraw Hill, 2017.

4. T. L. Floyd, Digital Fundamentals, (10e), Pearson Education, 2014.

5. W. Stallings, Computer Organization and Architecture–Designing for Performance, (8e), Pearson Education, 2010.

**H. Lecture Plan:**

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| --- | --- | --- | --- | --- | --- |
| **Lectures** | **Major Topics** | **Topics** | **Mode of Delivery** | **Corresponding CO** | **Mode Of Assessing CO** |
| **1** | **Digital logic circuits**  **Lecture 1-4** | Boolean algebra, logic gates, | **Lecture** | **2101.1** | Mid Term I, Quiz & End Term |
| **2** | map simplification, combinational circuits | **Lecture** | **2101.1** | Mid Term I, Quiz & End Term |
| **3-4** | sequential circuits, flip-flops | **Lecture** | **2101.1** | Mid Term I, Quiz & End Term |
| **5** | **Digital components:**  **Lecture 5-9** | Integrated circuits, decoders, | **Lecture** | **2101.1** | Mid Term I, Quiz & End Term |
| **6** | Multiplexers | **Lecture** | **2101.1** | Mid Term I, Quiz & End Term |
| **7** | Registers, shift registers, binary counters | **Lecture** | **2101.1** | Mid Term I, Quiz & End Term |
| **8** | Von-Neumann architecture | **Lecture** | **2101.1& 1301.3** | Mid Term I, Quiz & End Term |
| **9** | Performance | **Lecture** | **2101.1& 2101.3** | Mid Term I, Quiz & End Term |
| **10** | Machine Instructions and Programs ( Lecture 10-14) | Numbers, Arithmetic Operations And Characters | Flipped Class | **2101.2** | Mid Term I, Quiz & End Term |
| **11** | Memory Locations and Addresses, Memory Operations | Lecture | **2101.2** | Mid Term I, Quiz & End Term |
| **12** | Instructions and Instruction Sequencing | Lecture | **2101.2**& **2101.3** | Mid Term I, Quiz & End Term |
| **13** | addressing modes | Lecture | **2101.2**& **2101.3** | Mid Term I, Quiz & End Term |
|  | MID TERM I | | | |
| **14** | assembly language, additional instructions, encoding of machine instructions |  | **2101.2** |  |
| **15** | Arithmetic ( Lecture 15-29) | Addition and Subtraction of Signed Numbers | Flipped Class | **2101.2** | Mid Term I, Quiz & End Term |
| **16** | Design of Fast Adders | Lecture | **2101.2**& 1301.6 | Mid Term II, Quiz & End Term |
| **17** | Carry Look Ahead Adders- Bit Stage Cell,4 Bit CLA | Lecture | **2101.2**& 1301.5 | Mid Term II, Quiz & End Term |
| **18** | Carry Look Ahead Adders 16 Bit | Lecture | **2101.2**& 1301.5 | Mid Term II, Quiz & End Term |
| **19** | Tutorial | Activity | **2101.2** | Mid Term II, Quiz & End Term |
| **20** | Multiplication of Positive Numbers-Array Sequential Circuit | Flipped Class | **2101.2**& 1301.5 | Mid Term II, Quiz & End Term |
| **21** | Signed Operand Multiplication-Booth Algorithm | Lecture | **2101.2** | Mid Term II, Quiz & End Term |
| **22** | Fast Multiplication-Bit Pair Recoding Of Multipliers | Lecture | **2101.2** | Mid Term II, Quiz & End Term |
| **23** | Carry-save addition of summands | Flipped Class | **2101.2** | Mid Term II, Quiz & End Term |
| **24** | Integer Division-Restoring | Lecture | **2101.2** | Mid Term II, Quiz & End Term |
| **25** | Integer Division- Nonrestoring | Lecture | **2101.2** | Mid Term II, Quiz & End Term |
| **26** | Floating Point Numbers & Operation-Standards Exceptions, check to uncheck Exception | Lecture | **2101.2** | Mid Term II, Quiz & End Term |
| **27** | Arithmetic Operations on Floating Point Numbers | Lecture | **2101.2** | Mid Term II, Quiz & End Term |
| **28** | Examples on Arithmetic Operation on Floating Point Numbers | Lecture | **2101.2** | Mid Term II, Quiz & End Term |
|  | MIDTERM II | | | |
| **29** | Tutorial | Activity | **2101.2** | Mid Term II, Quiz & End Term |
| **30** | Memory Systems ( Lecture 30- 38) | Memory Systems: Basic Concepts | Flipped Class | **2101.4** | Mid Term II ,Quiz & End Term |
| **31** | Speed, Size & Cost | Lecture | **2101.4**& **2101.5** | Mid Term II ,Quiz & End Term |
| **32** | Cache Memories- Mapping Functions | Lecture | **2101.4**& **2101.5** | Mid Term II ,Quiz & End Term |
| **33** | Replacement Algorithms | Lecture | **2101.4**& **2101.5** | Mid Term II ,Quiz & End Term |
| **34** | Example Of Mapping Techniques | Flipped Class | **2101.4** | Mid Term II , Quiz & End Term |
| **35** | Performance Considerations: Hit Rate & Miss Penalty, Caches on Processor Chip | Lecture | **2101.4**& **2101.5** | Mid Term II , Quiz & End Term |
| **36** | Virtual Memories | Lecture | **2101.4**& **2101.6** | Mid Term II , Quiz & End Term |
| **37** | Address Translation | Lecture | **2101.4** | Mid Term II , Quiz & End Term |
| **38** | Tutorial | Activity | **2101.4** | Mid Term II , Quiz & End Term |
| **39** | Input / Output Processing ( Lecture 39-42) | Accessing I/O Devices, Interrupts | Lecture | **2101.5** | Quiz & End Term |
| **40** | Interrupt H/W, Enabling Disabling Interrupts | Lecture | **2101.5** | Quiz & End Term |
| **41** | Handling Multiple Devices, Controlling Device Requests, Exceptions | Lecture | **2101.5** | Quiz & End Term |
| **42** | Use of interrupts in Operating Systems, Direct Memory Access | Lecture | **2101.5** | Quiz & End Term |
| **43** | Instructional Level Parallelism (Lecture 43-49) | Flynn Classification, Multi-Core Architecture | Lecture | **2101.5**&**2101.6** | Quiz & End Term |
| **44** | Pipelining | Flipped Class | **2101.5** | Quiz & End Term |
| **45** | Data Hazards | Lecture | **2101.5** | Quiz & End Term |
| **46** | Instruction Scheduling: Static and Dynamic | Lecture | **2101.6**& **2101.6** | Quiz & End Term |
| **47** | Control Hazard | Lecture | **2101.5** | Quiz & End Term |
| **48** | Branch Prediction | Lecture | **2101.5** | Quiz & End Term |
| **49** | Tutorial | Activity | **2101.5** | Quiz & End Term |
|  |  | ENDTERM | | | |

1. **Course Articulation Matrix: (Mapping of COs with POs)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CO** | **STATEMENT** | CORRELATION WITH PROGRAM OUTCOMES | | | | | | | | | | | | CORRELATION WITH PROGRAM SPECIFIC OUTCOMES | | | |
| PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 | PSO4 |
| **2101.1** | Describe the interconnection between various functional units of a computer system and able to assess the performance of a computer. | 2 | 1 |  |  |  |  |  |  |  |  |  | 1 | 2 | 1 |  |  |
| **2101.2** | Describe various data representations and analyse the design of fast arithmetic circuits. | 3 | 2 |  |  |  |  |  |  |  |  |  | 1 | 1 | 1 |  |  |
| **2101.3** | Formulate assembly language programs for a given high level language construct. | 2 | 2 | 1 |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  |
| **2101.4** | Describe various parts of a system memory hierarchy and caching techniques. | 3 | 2 |  |  |  |  |  |  |  |  |  | 1 |  | 1 | 1 |  |
| **2101.5** | Evaluate the performance of CPU, memory and I/O operations. | 3 | 2 | 1 |  |  |  |  |  |  |  |  | 2 | 1 | 1 | 2 |  |
| **2101.6** | Build the required skills to read and research the current literature in computer architecture. |  |  |  |  |  |  |  |  |  |  |  | 2 | 1 |  |  | 1 |

1. **Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**