COURSE TITLE	**DIGITAL CIRCUITS**
COURSE CODE	**01EC0113**
COURSE CREDITS	**5**

Objective:

1 To equip students with foundational knowledge and practical skills in digital electronics, enabling them to analyze, simplify, and design combinational and sequential logic circuits, interface digital systems, and understand processor fundamentals using modern tools and techniques for applications in embedded, computing, and communication systems in future courses.

Course Outcomes: After completion of this course, student will be able to:

1 Apply number systems, Boolean algebra, and logic gates to design and implement combinational and sequential logic circuits. (Bloom's Level: Apply)

2 Analyze Combinational and Sequential Circuits for Optimal Performance. (Bloom's Level: Analyze)

3 Evaluate and troubleshoot digital systems for correctness and performance. (Bloom's Level: Evaluate)

4 Design Digital Circuits for Problem Solving using combinational and sequential components. (Bloom's Level: Create)

Pre-requisite of course: Basic knowledge of Electronic Components.

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
4	0	2	50	30	20	25	25

Contents : Unit	Topics	Contact Hours
1	**Introduction to Digital Electronics** Analog vs. digital signals, Applications of digital systems, voltage levels, digital waveform analysis	2
2	**Number Representation** Introduction to Binary, Octal, Decimal, and Hexadecimal number systems and their conversions., Binary arithmetic: addition, subtraction, multiplication, division., Subtraction using 1's and 2's complements., Fixed and floating point number representation., Binary codes: BCD, Excess-3, Gray Code, ASCII, and basic error detection codes.	5

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Contents : Unit	Topics	Contact Hours
3	**Logic Gates & Circuits** Introduction to Basic Gates: AND, OR, NOT and their truth tables. Universal Gates: NAND and NOR with gate-level realization of basic functions. Special Gates: XOR and XNOR with logic expressions and applications., SOP (Sum of Products) and POS (Product of Sums) forms and simplification., Logic circuit implementation from truth tables using SOP/POS., Logic Gate IC identification and Static CMOS Implementation of Logic Gates.	6
4	**Boolean Algebra & Logic Simplification** Boolean algebra laws and identities with simplification techniques., DeMorgan's theorems and their application in logic simplification., Karnaugh Maps (K-map), Quine-McCluskey method	4
5	**Combinational Circuit Design** Adders (Half and Full) and Subtractors (Half and Full) with circuit design., Multiplexers and Demultiplexers – working, design, and applications., Encoders, Decoders, and Comparators – functionality and circuit implementation., Applications of combinational circuits – Code Converters (e.g., BCD to 7-segment, Gray to Binary).	6
6	**Latches & Flip-Flops** Introduction to Sequential Circuits: State Equation, State Table, and State Diagram., SR and D Flip-Flops – working, characteristic table, and excitation table., T and JK Flip-Flops – operation, truth tables, and characteristic equations., Flip-Flop conversions: SR, D, T, JK with conversion techniques., Edge triggering vs. Level triggering – definitions, timing diagrams, and comparisons., Race-around condition in JK flip-flop – causes, examples, and solutions using Master-Slave flip-flops.	6
7	**Sequential Circuits** Counters – Asynchronous and Synchronous (up, down, and mod-N design)., Shift Registers – SISO, SIPO, PISO, PIPO and their applications., Finite State Machines (FSMs) – Mealy and Moore models with examples., Sequence Detectors – design using FSM (e.g., detecting specific binary patterns)., Static Timing Analysis – propagation delay, critical path, setup and hold time., Applications – Digital Clock, Event Counter, Digital Lock, and related logic design.	10
8	**Logic Families** Introduction to Logic Families: DTL and TTL – basics and working principles., CMOS Logic Family – operation, advantages, and comparison with DTL and TTL., ECL Logic Family – features and high-speed applications., Interfacing logic families and characteristics: noise margin, speed, power dissipation, fan-in, and fan-out.	4
9	**Data Converters** Sample & Hold Circuit – working principle and importance in ADC systems., Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC) – types, working, and applications.	4

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Contents : Unit	Topics	Contact Hours
10	**Memory and PLDs** Memory Devices: RAM, ROM, PROM, EPROM, and Flash – types and characteristics., Programmable Logic Devices: PLAs and PALs – structure and applications., Introduction to CPLD and FPGA – architecture, features, and basic differences.	3
11	**Introduction to Computer Organization** Machine Instructions and Addressing Modes – types and formats., ALU Design – components, operations, and functionality., Data Path – structure and role in instruction execution., Control Unit – design approaches (hardwired and microprogrammed)., Instruction Cycle – fetch, decode, execute, and timing.	6
Total Hours		**56**

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	**Experiment-1** Verify truth tables of basic gates (AND, OR, NOT) using ICs	2
2	**Experiment-2** Implement universal gates (NAND, NOR) as basic gates on breadboard	2
3	**Experiment-3** Simulate XOR, XNOR gates and implement logic expressions in SOP/POS form.	2
4	**Experiment-4** Design a logic circuit from a given truth table and implement it using ICs	2
5	**Experiment-5** Simulate number system conversion circuits (binary - BCD, Gray, Excess-3)	2
6	**Experiment-6** Perform binary addition, subtraction using 2’s complement method	2
7	**Experiment-7** Design and simulate 4-bit binary adder/subtractor circuit	2
8	**Experiment-8** Simplify logic expressions using Karnaugh Maps and implement simplified circuit	2
9	**Experiment-9** Use Quine-McCluskey method for SOP/POS minimization	2
10	**Experiment-10** Design and implement 2-bit half adder and full adder using logic ICs	2
11	**Experiment-11** Design and simulate 4-bit parallel adder using full adders	2

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Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
12	**Experiment-12** Implement 4:1 multiplexer and 1:4 demultiplexer using ICs	2
13	**Experiment-13** BCD to 7-segment display decoder using IC 7447 and display	2
14	**Experiment-14** Design a 3-bit comparator using logic gates	2
15	**Experiment-15** Verify SR, D, JK flip-flop behavior using ICs; observe edge triggering	2
16	**Experiement-16** Simulate flip-flop timing diagrams and race-around condition.	2
17	**Experiement-17** Design and implement 4-bit asynchronous/synchronous counter using IC 7490/74193	2
18	**Experiment-18** Simulate a sequence detector using FSM concept (e.g., detect “1011”)	2
19	**Experiment-19** Design and simulate 4-bit shift register (SIPO, PISO)	2
20	**Experiment-20** Visualize propagation delay, setup & hold time using simulated circuits.	2
21	**Experiment-21** Compare characteristics of TTL vs CMOS inverters (simulation: input/output, delay)	2
22	**Experiment-22** Simulate a basic 4-bit DAC and ADC (e.g., R-2R ladder)	2
23	**Experiment-23** Simulate ROM and RAM behavior with address decoding logic	2
24	**Experiment-24** Demonstrate logic implementation using PLA/PAL (tool-based like Logisim or Xilinx ISE)	2
25	**Experiment-25** Visualize instruction cycle stages (Fetch-Decode-Execute) using animated simulation	2
26	**Experiment-26** Simulate a basic 4-stage instruction pipeline and observe instruction flow	2
27	**Note** Minimum 24 experiments to be performed during the semester.	0

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Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
28	**Capstone Project** As a capstone project, students will design a digital system, such as a smart access control, low-cost diagnostic tool, or real-time alert system, addressing societal or industrial challenges using programmable hardware and/or digital electronic components.	0
Total Hours		**52**

Textbook :

1 Digital Fundamentals, Thomas L. Floyd and R.P.Jain, Pearson Education, 2012

2 Digital Design, M. Morris Mano and Michael D. Ciletti, Pearson, 5th Edition , 2013

References:

1 Digital Electronics: Principles, Devices and Applications, , Digital Electronics: Principles, Devices and Applications, , Anil K. Maini, Wiley India Pvt. Ltd, 2008

2 Fundamentals of Digital Circuits, Fundamentals of Digital Circuits, A. Anand Kumar, PHI Learning Pvt. Ltd., Fourth Edition , 2016

3 Digital Design and Computer Architecture, Digital Design and Computer Architecture, David A. Harris & Sarah L. Harris, Morgan Kaufmann, 2nd Edition, 2015

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation					
Remember / Knowledge	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Higher order Thinking / Creative**
10.00	10.00	30.00	20.00	10.00	20.00

Instructional Method:

1 The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

2 The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.

3 A practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.

4 Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

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Supplementary Resources:

1. Online Course on NPTEL, Digital Circuits by Prof. Santanu Chattopadhyay (IIT Kharagpur), Link: https://nptel.ac.in/courses/117105080 , Features: Free video lectures, assignments, and certification (optional via SWAYAM), Level: Undergraduate (Engineering Core Course)
2. Online Course on Coursera, Digital Systems: From Logic Gates to Processors by Universitat Autònoma de Barcelona, Link: https://www.coursera.org/learn/digital-systems , Features: Covers digital logic, combinational and sequential circuits, and processor design, Certification: Available (paid), Level: Intermediate
3. Online Course on Udemy: Digital Electronics: Robotics, learn by building module 1 by Ian Juby, Link: https://www.udemy.com/course/digital-electronics-robotics-learn-by-building/ , Features: Practical, project-based learning with real-world applications in robotics, Certification: Available, Level: Beginner to Intermediate
4. Online Course on NPTEL, Prof. Goutam Saha (IIT Kharagpur), https://onlinecourses.nptel.ac.in/noc20_ee32/preview?utm_source=chatgpt.com
5. Online Course on Coursera, https://www.coursera.org/learn/digital-systems

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