Curriculum Committee Approval: 02/20/2024

Lecture Contact Hours: 48-54; Homework Hours: 96-108;
Laboratory Contact Hours: 48-54; Homework Hours: 0;
Total Student Learning Hours: 192-216

CUYAMACA COLLEGE
COURSE OUTLINE OF RECORD

ENGINEERING 270 – DIGITAL DESIGN

3 hours lecture, 3 hours laboratory, 4 units

Catalog Description
Modeling, analysis, simulation, design and construction of combinational and sequential digital logic systems and networks.

Prerequisite
“C” grade or higher or “Pass” in MATH 175 or 176 or equivalent

Entrance Skills
Without the following skills, competencies and/or knowledge, any student entering this course will be highly unlikely to succeed:
1) Apply critical thinking and mathematical reasoning skills necessary in collegiate-level algebraic problem solving in disciplines such as science, business and engineering.

Course Content
1) Number systems and conversion, binary arithmetic, representation of negative numbers, and binary codes
2) Boolean algebra: basic operations, Boolean expressions and truth tables, basic theorems, commutative, associative and distributive laws, simplification theorems, DeMorgan’s laws
3) Minterm and maxterm expressions
4) Conversion of English sentences to Boolean equations. Combinational logic design using a truth table
5) Minimum forms of switching functions: two-, three-, four- and five-variable Karnaugh maps
6) Multi-level gate circuits
7) Combinational circuit design. Design of circuits with limited gate fan-In. Gate delays and timing diagrams
8) Simulation and testing of logic circuits
9) Multiplexers, three-state buffers, decoders and encoders, read-only memories, programmable logic devices
10) Latches and flip-flops
11) Registers and counters
12) Analysis of clocked sequential circuits
13) State graphs and tables
14) Sequential circuit design
15) VHDL (Very High Speed Integral Circuit Hardware Description Language) for digital circuit design

Course Objectives
Students will be able to:
1) Do arithmetic in the binary, octal, decimal and hexadecimal number systems and convert from one to another.
2) Design and build multi-level gate circuits, adders, multiplexers, decoders, and other combinational circuits starting from a verbal description, a truth table, or a Boolean output function. Apply Boolean algebra, Karnaugh maps, and “don’t care” conditions to simplify and optimize circuits.

3) Analyze a combinational circuit to determine the associated truth table and Boolean output function.
4) Explain the operation of a ROM (Read-only memory), PLD (programmable logic device), CPLD (complex programmable logic device), and FPGA (field programmable gate array).
5) Design and build flip-flops, registers, counters, and clocked sequential circuits (Moore and Mealy machines) starting from a verbal description, a state table, a state diagram, or a timing diagram.
6) Simplify sequential circuits through redundant state analysis, the judicious use of state assignments, and one-hot encoding.
7) Conduct state and timing analysis of sequential logic circuits.
8) Apply VHDL (Very High Speed Integral Circuit Hardware Description Language) to simulate and build combinational and sequential logic circuits.
9) Document all aspects of the design and testing of a digital circuit.

Method of Evaluation

A grading system will be established by the instructor and implemented uniformly. Grades will be based on demonstrated proficiency in subject matter determined by multiple measurements for evaluation, one of which must be essay exams, skills demonstration or, where appropriate, the symbol system.

1) Classroom assessment tools including reading quizzes, concept quizzes, attention quizzes, muddiest point questions, and one-minute papers that measure students' ability to apply concepts just discussed in class. An example would be a multiple choice question answered using an audience response system in which students rapidly subtract 11011 from 10001, applying one's complement number representations.
2) Homework that requires students to interact with the course material outside the classroom and to evaluate their ability to extend the classroom and reading experience to novel situations. Question types include word problems requiring calculations and analysis of graphical data and short answer questions. An example would be a design problem to design a Mealy sequence detector using JK flip-flops that will detect either of the following binary sequences: 1101 or 1001.
3) Periodic quizzes and midterm examinations to evaluate student learning and retention of the material on the time scale of weeks. Question types include word problems requiring calculations and analysis of graphical data and short answer questions. An example would be a design problem to design a Mealy sequence detector using D flip-flops that will detect either of the following binary sequences: 1101 or 1001.
4) Final examination to evaluate students' ability to integrate the course material as a whole and to assess overall retention of the material. Question types include word problems requiring calculations and analysis of graphical data and short answer questions. An example would be a design problem to design a Moore sequence detector using D flip-flops that will detect either of the following binary sequences: 1101 or 1001.
5) Laboratory notebooks that measure students' ability to apply theory from text and lecture to the development of real working circuits and to document the development from first concept to final verification. An example would be to design an electronic combination lock that will open after the sequence 7-4-5 is given to it, with the input value being displayed on a 7-segment display, and a correct sequence being rewarded with a green light.

Special Materials Required of Student

Access to computer

Minimum Instructional Facilities

1) Smart classroom
2) Laboratory with digital logic stations and computers

Method of Instruction

1) Lecture and demonstration
2) Laboratory assignments

Out-of-Class Assignments

1) Weekly homework including assigned reading and problem solving
2) Group projects

Texts and References

1) Required (representative examples):
    a. Roth, Charles H. *Fundamentals of Logic Design*. 7th edition. Thomson, 2020.
    b. Mano, Morris M., Kime, Charles R., Martin, Tom *Logic & Computer Design Fundamentals*. 5th Edition. Pearson, 2016.
2) Supplemental: None

Exit Skills

Students having successfully completed this course exit with the following skills, competencies and/or knowledge:

1) Do arithmetic in the binary, octal, decimal and hexadecimal number systems and convert from one to another.
2) Design and build multi-level gate circuits, adders, multiplexers, decoders, and other combinational circuits starting from a verbal description, a truth table, or a Boolean output function. Apply Boolean algebra, Karnaugh maps, and “don’t care” conditions to simplify and optimize circuits.
3) Analyze a combinational circuit to determine the associated truth table and Boolean output function.
4) Explain the operation of a ROM (Read-only memory), PLD (programmable logic device), CPLD (complex programmable logic device), and FPGA (field programmable gate array).
5) Design and build flip-flops, registers, counters, and clocked sequential circuits (Moore and Mealy machines) starting from a verbal description, a state table, a state diagram, or a timing diagram.
6) Simplify sequential circuits through redundant state analysis, the judicious use of state assignments, and one-hot encoding.
7) Conduct state and timing analysis of sequential logic circuits.
8) Apply VHDL (Very High Speed Integral Circuit Hardware Description Language) to simulate and build combinational and sequential logic circuits.
9) Document all aspects of the design and testing of a digital circuit.

Student Learning Outcomes

Upon successful completion of this course, students will be able to:

1) Analyze a combinational circuit to determine the associated truth table and Boolean output function.
2) Conduct state and timing analysis of sequential logic circuits.
3) Apply VHDL (Very High Speed Integral Circuit Hardware Description Language) to simulate and build combinational and sequential logic circuits.
4) Document all aspects of the design and testing of a digital circuit.