CMPEN 270
Digital Design: Theory and Practice
Required Course in Computer Engineering

Catalog Data:
Digital Design: Theory and Practice (3)
Introduction to digital systems and their design. Topics include combinational and
sequential devices and circuits, modern design tools and design practices. Prerequisite:
Physics 212.

Typical Textbook:
Introduction to Logic Design, by Alan B Marcovitz, 2nd Edition

Course Objectives:
CMPEN 270 is a first course in digital systems and digital system’s design. It lays the
groundwork for many later courses in computer organization and architecture and
switching theory. The course includes both a lecture component to introduce important
concepts, principles, methodologies and theories and a laboratory component in which
the lecture material can be applied and practiced. The course introduces the theoretical
foundation for digital systems including number systems, a variety of commonly used
codes and Boolean algebra. Combinational devices, logic gates, and sequential devices,
latches and flip-flops are introduced along with design techniques, methods and tools.
Design criteria and objectives are considered and design trade-offs are examined. Higher
level design elements are also examined such as decoder, multiplexers, counters, and
registers, and their use in system design. Students are exposed to a variety of design
tools and implementation techniques, including schematic capture tools, simulation tools,
Hardware Description Language (HDL) and HDL design tools. Laboratory work
includes the design, construction and debugging of a variety of digital circuits, and the
use of standard laboratory tools such as the oscilloscope and logic analyzer, and various
software design tools.

Primary Course Outcomes:
Upon completion of the course, students should possess the following skills:

- Be able to manipulate numeric information in different forms, e.g. different bases,
signed integers, various codes such as ASCII, grey, and BCD.
- Be able to manipulate simple Boolean expressions using the theorems and postulates
  of Boolean algebra and to minimize combinational functions using either hand or
electronic tools.
- Be able to design and analyze small combinational circuits and to use standard
  combinational functions/building blocks to build larger more complex circuits.
  (Program Outcome 4)
- Be able to design and analyze small sequential circuits and devices and to use standard
  sequential functions/building blocks to build larger more complex circuits. (Program
  Outcome 4)
- Be able to use typical logic analysis, debug and design tools. (Program Outcome 1)
- Be able to use standard digital laboratory equipment to aid in the design,
  implementation, and debugging of combinational and sequential circuits. (Program
  Outcome 1)
- Be able to implement combinational and sequential circuits using typical
  breadboarding techniques and/or other implementation technologies. (Program
  Outcome 1)
- Be able to record laboratory and experimental results in a professional manner.
  (Program Outcome 12)

Relationship to Undergraduate
Program Outcomes:
- Program Outcome 1: Demonstrate basic laboratory skills, including the use of
  standard laboratory equipment.
- Program Outcome 4: Design the electronic/logic circuits that form the basic building
  blocks of a computer system.
- Program Outcome 12: Write clear and effective technical prose.
Required Topics: Logic Gates and Signals (2 lectures)
CMOS/TTL Logic - Properties and Characteristics (2 lectures)
Number Systems & Codes (2 lectures)
Arithmetic and Arithmetic Circuits (2 lectures)
Boolean Algebra (1 lecture)
Combinational Circuit Analysis (1 lecture)
Combinational Circuit Design and Minimization (3 lectures)
Design Tools - Schematic Capture, Hardware Description Languages, Simulation (1 lecture)
Functional vs Electrical vs Timing Design Considerations (1 lecture)
Programmable Logic Devices: PAL, PLA/GAL, CPLD, FPGA (2 lectures)
Timing Diagrams (1 lecture)
Hardware Description Languages, e.g. VHDL, ABEL (5 lectures)
MSI Combinational Devices/Functions: Decoders/Demultiplexers, Encoders, Multiplexers (3 lectures)
Sequential Circuits and Devices: Latches and Flip-Flops (2 lectures)
Synchronous Sequential Circuit Analysis (2 lectures)
Synchronous Sequential Circuit Design: (5 lectures)
Hazards (1 lecture)
MSI Sequential Devices/Functions: Counters, Registers (3 lectures)
3 State Outputs, Buses, Special Inputs/Devices (2 lectures)
Memory Devices (1 lecture)
System Design Considerations (1 lecture)

Class Format: Three 50 minute lectures per week. One two hour laboratory per week.

Professional Component: CMPEN 270 aids in the professional development of students by providing a foundation of knowledge needed in the profession. It also introduces students to the design process and the need to consider multiple design criteria and the attendant process of trading off conflicting design constraints. Students are exposed to some of the current topics in the discipline.

Evaluation: Students are evaluated through the completion of a series of individual homework assignments, a series of 13 or 14 laboratory projects (completed in groups of 2), and 3 or 4 examinations.

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Last Revised: June 9, 2008