

Elizabethtown College

EGR 330 Digital Design and Embedded Systems Lecture & Lab

Fall 2022

Design of combinational and sequential digital logic circuits, and their use in computer architectures. Introduction to machine instructions and assembly language programming. Lectures include design of embedded systems, microcontrollers, and microprocessors. Laboratory use of Breadboarded IC circuits, Logic Simulators, Programmable Logic Controllers (PLCs), Assembly Language simulators, and periodically Raspberry Pi's and Arduinos. Introduction to Field Programmable Gate Arrays (FPGAs). Custom lab manuals.

**Prerequisite(s):* CS 121 or permission of the instructor. Fall semester, even-numbered years.

This course is a mandatory prerequisite for [EGR/CS433\(430\) Advanced Computer Engineering \(Parallel Processing\)](#)

PROFESSOR

Joseph T Wunderlich PhD

Associate Professor of Engineering and Computer Science

Coordinator of Computer Engineering and Architecture

Offices: E284E and E273 Office Phone: 717-361-1295 Cell Phone: 717-368-9715

Email: wunderjt@etown.edu Website: <http://users.etown.edu/w/wunderjt>

Office Hours: [http://users.etown.edu/w/wunderjt/schedules/Wunderlich Schedule Card Fall 2022.pdf](http://users.etown.edu/w/wunderjt/schedules/Wunderlich%20Schedule%20Card%20Fall%202022.pdf)

MEETING TIMES (for 6 contact hours = 300 minutes)

MONDAY 2:00pm - 3:05pm (Lecture)

WEDNESDAY 2:00pm - 3:05pm (Lecture)

FRIDAY 2:00pm - 4:50pm (Lab)

COURSE TEXTS, MANUALS, AND READINGS

- Arijit Saha and Nilotpal Manna, "*Digital Principles and Logic Design*," 1st edition, January 28, 2009, Jones & Bartlett Publishers, (ISBN: 978076377373).
- Excerpts posted in Canvas from:
 - Kenneth Ayala, "*8051 Microcontroller: Architecture, Programming and Applications*," 2 edition, September 26, 1996 – this one is much better than the newer editions), Delmar Learning, (ISBN: 9780314201881).
 - Frank D. Petruzella, "*Programmable Logical Controllers*," 4th edition, September 3, 2010, McGraw-Hill Science/Engineering/Math, (ISBN: 0073510882).

Custom Lab Manuals:

1. [2018 IC's, Circuit Trainer, and Power Supply](#)
2. [2022 Intel 8051 Microcontroller Simulator VIDEO Manual](#)
3. [2022 Intel 8051 Microcontroller Simulator VIDEO example](#)
4. [2019 Intel 8051 Microcontroller](#) (2015, 2014, Pre-2013)
5. [2019 Relays](#)
6. [2019 NanoLC PLC\(Programmable Logic Controller\)](#)
7. [2019 AXIOLINE PLC](#)
8. [2021 PLC-NEXT VIDEO Tutorial](#)
9. [2021 connecting PLC-NEXT to AXIOLINE using PROFINET Comm. VIDEO Tutorial](#)
10. [2022 Twenty-three years of Etown FPGA's](#)
11. [2022 FPGA Verilog HDL & Gate-level Simulator \(and waveforms\) "Vivado" VIDEO Tutorial](#) (IDE requires 100 GigaBytes on Hard-drive)
12. [2019 FPGA for HDL \(Hardware Description Language\)](#)
13. [2018 FPGA for Gate-Level Circuit Design, and critical Waveforms/Timing design \(2018A, 2013, pre-2013\)](#)
14. [2019 Rasberry Pi and ARM Microcontroller](#)

GRADING

5% Attendance and participation

65% Labs and Projects

30% Exams

Course Grade:

(60-62)=D-, (63-67)=D, (68-69)=D+, (70-72)=C-, (73-77)=C, (78-79)=C+, (80-82)=B-, (83-87)=B, (88-89)=B+, (90-92)=A-, (93-100)=A
(with any fractional part rounded to the nearest integer)

LEARNING OUTCOMES

1. Digital Combinational Circuit Design
2. Analysis of Digital Synchronous devices
3. Digital Sequential Circuit Design
4. Embedded systems design
5. Breadboard circuit implementations
6. Programmable Logic Controllers (PLC's) implementations
7. Microcontroller Assembly language
8. Introduction to Field Programmable Gate Arrays

EGR 330 Digital Design and Embedded Systems

Lecture & Lab

Fall 2022

COURSE OUTLINE

COMBINATIONAL DIGITAL CIRCUIT DESIGN

- Example with [Wunderlich 8 STEPS OF COMBINATIONAL](#) Digital Circuit Design
- Digital Circuit Basics
- Boolean Algebra. Circuit Re-Design Proofs (all else moved into new course in "Applied Discrete Math")
- Design using K-Map simplification for Two, Three, Four, & Five variables; Derivation of Maps
- Digital Circuit Simulators (Logisim, Xilinx) vs. Real-Time circuit implementations
- ETOWN MANUAL 2018 IC's, Circuit Trainer, and Power Supply [PDF](#) [MP4 YouTube](#) (Fan-out, etc.)
 - Pull-up and LED Current-limiting Resistors, Floating Pins, etc. (1,2)
 - List of 7400-series integrated circuits
- Don't-Care conditions, Code Converter
- XOR-Pattern non-SOP functions Just for Reference: Non-linear-Separability (slide#8) in Neural Networks [PPTX-w/audio PDF MP4 YouTube](#)
- Voting Machine, Display Controller

----- VIDEO REVIEW 1; FOR ALL ABOVE: [MP4 YouTube](#)

- AD-HOC DESIGNS (i.e., no Design "STEPS")
 - 2-bit-Adder into Bit-Sliced, Scalability [AD-HOC Full Adder](#) [Half-Adder](#)
 - 2-bit-Subtractor into Bit-Sliced, Scalability [AD-HOC Adder/Subtractor](#)
 - Two's Complement Number Representations [PPTX-w/audio PDF MP4 YouTube](#) (IEEE BFP Binary Floating Point just for reference)
 - Just for Reference: IEEE BFP [PDF PPTX-w/audio MP4 YouTube](#), Fractional-part [PDF PPTX-w/audio MP4 YouTube](#)
 - 2-bit-Multiplier into Scalability [AD-HOC Multiplier](#)
- FUNCTIONAL BLOCKS (to build larger circuits) – without internal designs: :HalfAdder,FullAdder,Multiplier,Decoder,Multipexor(MUX),Encoder,DeMultiplexor
 - Internal designs: Decoder, Multiplexor(MUX)

----- VIDEO REVIEW 2; FOR ALL ABOVE SINCE LAST REVIEW: [MP4 YouTube](#)

SEQUENTIAL DIGITAL CIRCUIT ANALYSIS & DESIGN

- Concept (Sequential w / Combinational nested within)
- WaveForms, Analysis & Design (Finite State Machines, [Wunderlich 13 STEPS OF SEQUENTIAL](#) Digital Circuit Design) More problems
- Design w/unused states More problems
- Digital Circuit Simulators vs. Real-Time circuit implementations
 - De-Bouncing switches(1,2,3)
- Counters More sample problems
- CPU Pipeline -- driven by a Finite State Machine
- CPU Design & Assembly Language intro

----- VIDEO REVIEW 3; FOR ALL ABOVE SINCE LAST REVIEW: [MP4 YouTube](#)

EXAMPLE GATE-LEVEL PROCESSOR DESIGN

- SC-16H CPU Design by Glen G Langdon [PPTX-w/audio PDF MP4 YouTube](#)

INTRO TO MICROCONTROLLERS & ASSEMBLY LANGUAGE

- Wunderlich, J.T. (1999). Focusing on the blurry distinction between microprocessors and microcontrollers. In *Proceedings of 1999 ASEE Annual Conference & Exposition, Charlotte, NC*: (session 3547), [CD-ROM]. ASEE Publications. [PDF MP4 YouTube](#)
- Intel 8051 Microcontroller
 - ETOWN VIDEO MANUAL 2022 Intel 8051 Microcontroller Simulator ETOWN VIDEO EXAMPLE 2022 Intel 8051 Microcontroller Simulator
 - Overview/architecture, Memory Map, PSW, Stack
 - Instruction Set (1,2), MOVES, LOGIC, MATH, JUMPS&CALLS (PPT,text), 80251

CIRCUIT ISOLATION

- ETOWN MANUAL 2019 Relays Phoenix Contact Relays
- Buffer-chips

PROGRAMMABLE LOGIC CONTROLLERS (PLC'S)

- Ladder-Logic PLC's Fundamentals Evolution
- ETOWN MANUAL 2019 NanoLC PLC previous version:2018 Example design
- ETOWN MANUAL 2019 AXIOLINE PLC
 - 2021 PLC-NEXT VIDEO Tutorial
 - 2021 connecting PLC-NEXT to AXIOLINE using PROFINET Comm. VIDEO Tutorial

SIMULATIONS VS. REAL-TIME CONTROL

- PENNSTATE: Wunderlich, J.T, and P. Swayne (1990). A Process Control Simulation Program of a Bottling Plant.
- PENNSTATE: Wunderlich, J.T. (1990). Areal-Time Process Control Program in Assembly Language, of a Bottling Plant.
- Wunderlich, J.T. (2001). Simulation vs. real-time control; with applications to robotics and neural networks. In *Proceedings of 2001 ASEE Annual Conference & Exposition, Albuquerque, NM*: (session 2793), [CD-ROM]. ASEE Publications. [PAPER](#)
- Campos, D. and Wunderlich, J. T. (2002). Development of an interactive simulation with real-time robots for search and rescue. In *Proceedings of IEEE/ASME Int'l conference on Flexible Automation, Hiroshima, Japan*: (session U-007).ASME Press. [PAPER](#)
- Robotics Sensors & Navigation Lecture from [EGR/CS434 Robotics & Machine Intelligence](#)

COMMUNICATION FUNDAMENTALS [PDF1](#) [PDF2](#)

INTRO TO FPGA'S (Field Programmable Gate Arrays) used in [EGR430/433 Parallel-Processing/Advanced-Computer-Engineering](#)

- ETOWN MANUAL 2019 FPGA for HDL (Hardware Description Language)
- ETOWN MANUAL 2018 FPGA for XILINX Gate-Level Circuit Design, and Waveforms/Timing design (2018A, 2013, pre-2013)
- ETOWN VIDEO TUTORIAL 2022 FPGA Verilog HDL & Gate-level Simulator (& waveforms) "Vivado" (IDE requires 100 GigaBytes on Hard-drive)

ATTENDANCE

Class participation is part of your course grade. Also, exams cover mostly material that is only presented in lecture. LARGE PENALTIES FOR MISSING LAB TIME (i.e., since teams)

SCHOOL CLOSURE / CLASS CANCELATION

Additional work assigned to cover any class cancelation

ACADEMIC HONESTY

Elizabethtown College Pledge of Integrity: *"Elizabethtown College is a community engaged in a living and learning experience, the foundation of which is mutual trust and respect. Therefore, we will strive to behave toward one another with respect for the rights of others, and we promise to represent as our work only that which is indeed our own, refraining from all forms of lying, plagiarizing, and cheating."*

See the 2016-17 Elizabethtown College Catalog, "Standards of Academic Integrity"

(http://catalog.etown.edu/content.php?catoid=10&navoid=507#Academic_Judicial_System)

or Academic Integrity at Elizabethtown College, 11th ed.

(<https://www.etown.edu/offices/dean-of-students/files/academic-integrity-handbook.pdf>)

DISABILITY SERVICES, RELIGIOUS OBSERVANCES, and COVID

https://elizabethtown-my.sharepoint.com/:w/g/personal/ouimetc_etown_edu/EfZ-QooKt_VPjgwsWJz230wB3Rb6CIHsPvE0xuqWCpr-UA?e=4%3acZzjpW&at=9

DISABILITY SERVICES: Elizabethtown College welcomes otherwise qualified students with disabilities and is committed to providing access for all students to courses, programs, services, and activities. If you have a documented disability such as a learning disability or chronic illness or a new circumstance such as a concussion and would like to request accommodations please contact the Director of Disability Services by phone (717-361-1227) or e-mail (daviesl@etown.edu). The Office of Disability Services can provide resources to you and facilitate communication with faculty about reasonable accommodations. After meeting with the Office of Disability Services, please set up an appointment to meet with me, the instructor, to discuss the accommodations as they pertain to my class.

RELIGIOUS OBSERVANCES: The College is eager to facilitate individual religious beliefs and practices whenever possible while retaining course student learning outcomes. It is your responsibility to meet with the class instructor in advance to request arrangements related to your religious observances that may conflict with this class, and to make appropriate plans to make up any missed work.

COVID-RELATED EXPECTATIONS: All students are expected to adhere to the established community expectations around safety, including: daily digital health reporting, physical distancing, proper wearing of facial coverings within buildings and classrooms and when within six feet of individuals outdoors, frequent handwashing, and participation in cleaning and sanitizing protocols as requested. You will be turned away from class if you do not have a face covering. Students diagnosed with a health condition that precludes mask wearing can contact Lynne Davies in Disability Services (daviesl@etown.edu) to request remote learning as a reasonable accommodation. **If you are exhibiting any symptoms of COVID or fail to pass the daily health screen, do not come to class.** Failure to adhere to the established community expectations around safety will result in notification of Campus Security and application of the student conduct process for failure to comply, endangering the well-being of others, and/or disorderly conduct. The student code of conduct applies also to participation in all virtual activities, including Zoom sessions and discussion boards.

MENTAL HEALTH & COUNSELING RESOURCES

Counseling Services provides a broad range of counseling and mental health support services that facilitate our students' personal, social, and academic development. Our licensed mental health professionals provide short-term individual counseling, group counseling, crisis intervention, and consultation to currently enrolled students for no additional charge. Counseling services are provided in a confidential and diversity-affirming environment to help students address a variety of mental health, situational, and developmental concerns. Our office is located in the Baugher Student Center, Suite 216. Appointments can be made in person or by calling 717-361-1405. Urgent walk-in services are also available. To access our after-hours crisis services, please call the 24/7 Campus Security number of 717-361-1111. For more information, please visit www.etown.edu/offices/counseling.