ENG 241: Digital Design
School of Engineering
University of Guelph
05-241
Fall 2009

**Course Outline**

**Prerequisites: PHY1130, CIS1500**

# Instructor


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|---|---|
| Prof: | Shawki Areibi. |
| Office: | 2335, ext. 53819 |
| Email: | sareibi@uoguelph.ca |
| Web Site: | http://www.uoguelph.ca/~ sareibi |
| Office Hours: | Thur 10:00 - 12:00. |


# Lab Coordinator & Teaching Assistant

| Lab Coordinator | Teaching Assistant |
|---|---|
| Nate Groendyk | Omar Ahmed |
| Room 2308, ext. 53873 | Room THORN 304, ext - |
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# Lecture & Lab Schedule

| | Day | Section | Time | Place |
|---|---|---|---|---|
| Lectures | Mon | 01/02 | 9:30 - 10:20 | MACK 236 |
| | Wed | 01/02 | 9:30 - 10:20 | MACK 236 |
| | Fri | 01/02 | 9:30 - 10:30 | MACK 236 |
| Laboratory | Wed | 01/02 | 11:30-13:20 | THRN 2307 |
| Tutorials | Thu | 01/02 | 12:30-13:20 | MACK 233 |

# Course Text

1. M. Morris Mano *Logic And Computer Design Fundamentals 4th Edition* Prentice Hall, 2008

# References

1. K. Short, *VHDL for Engineers*, 2nd Edition, Prentice Hall, 2008.
2. S. Yalamanchili, *VHDL, A Starter's Guide*, 2nd Edition, Prentice Hall, 2005.
3. VHDL Tutorial by Shawki Areibi.
4. Tutorial On Using Xilinx Foundation Design Tools.
5. Fundamentals of Digital Logic with VHDL Design by Brown and Vranesic.

# Course Contents, Goals and Objectives:

Digital hardware plays a prominent role in many electrical and computer engineering products today. This is principally due to the rapid increase in transistor densities and speed of integrated circuits and steep decline in their cost caused by the advance in micro-electronic implementation technologies. This trend is likely to continue in the foreseeable future.

This course is an introductory course in digital logic design, which is a basic course in most electrical and computer engineering programs. The main goals of the course are (1) to teach students the fundamental concepts in classical manual digital design and (2) to illustrate clearly the way in which digital circuits are designed today, using CAD tools. Throughout the course basic concepts are introduced by way of example that involve simple circuit design. The course will first introduce digital and computer systems and information representation. The course will then introduce the following topics: logic gates, boolean algebra, Karnaugh maps, design hierarchy, combinational circuit analysis and design, sequential circuit concepts and design, random access memory and programmable logic, algorithmic state machines (ASM) for controlling operations. Introductions to the hardware description languages, VHDL and Verilog, are provided with the expectation that at most one of the languages will be covered.

# Main Topics To Be Covered:

- Digital Computers and Information.
- Combinational Logic Design.
- Sequential Logic Design.
- Memory and Programmable Logic Devices.
- Hardware Descriptive Languages (VHDL).
- Data Path.
- Finite State Machines (Sequencing and Control).

# Relationships to other Courses & Labs:

ENG241 and its lab will teach you plenty about digital hardware, its specification, design and implementation. More importantly however, is that it prepares you for lower level hardware description languages (HDL) and their use in digital design. Several other courses in the curriculum expand on ENG241:

- **ENG338, Embedded Architecture Design:** This course concentrates on the issues that arise in engineering of larger digital systems. Its students are exposed to requirements specification, higher level hardware description languages, hardware/software co-design.
- **ENG364, Microcomputer Interfacing:** This course focuses on system and interfacing issues in the design of microprocessor-based digital systems. Among others, the course covers concepts in data acquisition and embedded systems.

# Resources

**Please pay attention** to the ENG2410 Digital Design Web Page. You will find the following useful information:

- **Lecture Information:** All the lecture notes are posted on the web page (week #1-#12).
- **Lab Information:** The handouts for all the lab sessions are within the lab section. All types of resources regarding tutorials, links to web pages can be found in this section.
- **Assignments:** Download the assignments according to the schedule given in this handout. All the solutions will be posted as indicated.
- **Exams:** Some midterms and finals of previous years are posted as samples of exams. The solutions are also posted for your convenience.
- **Miscellaneous Information:** Other information related to Digital Design are also posted on the web page i.e Frequently Asked Questions, News Groups, links to similar courses e.t.c.

# Tentative Schedule

| Week | Date | Lecture Material | # Lectures | Source |
|---|---|---|---|---|
| #1 | Sep 14-Sep 18 | Introduction to Digital Design | 3 Lecs | Chapter 1,2 |
| #2 | Sep 21-Sep 25 | Combinational Logic Circuits | 3 Lecs | Chapter 2 |
| #3 | Sep 28-Oct 02 | Combinational Logic Design | 3 Lecs | Chapter 2,3 |
| #4 | Oct 05-Oct 09 | Combinational Logic Design Examples | 3 Lecs | Chapter 3 |
| #5 | Oct 12-Oct 16 | Arithmetic Circuits | 3 Lecs | Chapter 5 |
| #6 | Oct 19-Oct 23 | Sequential Circuits | 3 Lecs | Chapter 6 |
| #7 | Oct 26-Oct 30 | Sequential Circuit Design Examples | 3 Lecs | Chapter 6 |
| #8 | Nov 02-Nov 06 | Registers and Counters | 3 Lecs | Chapter 7 |
| #9 | Nov 09-Nov 13 | RTL Register Transfer and Data Path | 3 Lecs | Chapter 7 |
| #10 | Nov 16-Nov 20 | Control and ASMs | 3 Lecs | Chapter 8 |
| #11 | Nov 23-Nov 27 | Memory | 3 Lecs | Chapter 9 |
| #12 | Nov 30-Dec 04 | Programmable Logic Devices | 3 Lecs | Chapter 3 |

# Assignments

There will be 10 assignments throughout the term. **Solve all problems** and hand in your assignment to the teaching assistant in the tutorial and you will get 5 marks. It is in your interest to solve all assignments alone without any help since many questions of the midterm and final exam will be based on these assignments. Solutions will be posted on the web every other week.

| Item | Handed In | Due Date | Topic |
|---|---|---|---|
| Assign #1 | (Week #1) | Week #2 | Number Systems |
| Assign #2 | (Week #2) | Week #3 | Boolean Algebra |
| Assign #3 | (Week #3) | Week #4 | K-Map simplification |
| Assign #4 | (Week #4) | Week #5 | Combinational logic Design |
| Assign #5 | (Week #5) | Week #7 | Arithmetic Circuits |
| Assign #6 | (Week #7) | Week #9 | Sequential Circuits |
| Assign #7 | (Week #9) | Week #10 | Registers and Counters |
| Assign #8 | (Week #10) | Week #11 | Data Path Circuits |
| Assign #9 | (Week #11) | Week #12 | Algorithmic State Machines |
| Assign #10 | (Week #12) | - | Memory & Programmable Logic |

# Labs

ENG241 labs are an integral part of the course. The objectives of the laboratories are:

- to help you understand and assimilate the lecture material.
- to give you practical experience with the process of design and implementation of digital circuits.
- to teach you design entry based on Hardware Description Languages.
- to give you hands-on-experience with CAD tools for digital hardware development.

There will be 8 labs throughout the term. The following are the due dates.

| Item | Takes Place | Due Date | Topic |
|---|---|---|---|
| Lab #0 | (Week #02) | - | Introduction to Lab Equipment |
| Lab #1 | (Week #03) | (Week #04) | Combinational Logic & TTL |
| Lab #2 | (Week #04) | (Week #05) | ISE Schematic Capture Tutorial |
| Lab #3 | (Week #05) | (Week #06) | ISE VHDL Design Entry Tutorial |
| Lab #4 | (Week #06) | (Week #07) | Combinational Logic Design |
| Lab #5 | (Week #07) | (Week #08) | Design with VHDL |
| Lab #6 | (Week #08) | (Week #09) | Sequential Logic Design |
| Lab #7 | (Week #09) | (Week #10) | Data Path Design |
| Lab #8 | (Week #10) | (Week #11) | Algorithmic State Machines |

# Exams

Midterms and a Final Exam will be conducted on the dates as shown in the table below. The following is the exam and quiz schedule:

| Item | Week | Date | Location | Time | Topic |
|---|---|---|---|---|---|
| Midterm #1 | 4 | Thur Oct 8th | Mack 233 | 12:30 PM | Week 1-3 |
| Midterm #2 | 8 | Thur Nov 5th | Mack 233 | 12:30 PM | Week 4-7 |
| Final Exam | 13 | Dec 7th | TBA | TBA | Topics on Weeks #1 up-to #12 |

# Evaluation

- It is important to note that the quizes, midterms and final exam will be based on the assignment problems, so it is definitely in your interest to seriously attempt to do them all **alone**.
- You will save much time if you thoroughly study the relevant sections of the lab handouts before attempting the experiments in the lab. Come to the lab. with a clear understanding of what you are meant to accomplish, or with clear questions, so that the teaching assistant can help you.

| Topic | Weight | Details | Comments |
|---|---|---|---|
| Assignments | 5 % | 10 assignments | Solve all problems and hand in during Tutorial |
| Quizes | 5 % | 2 Quizes | During Class or Tutorial (any time!) |
| Labs | 15 % | 8 Labs | Preparation, report, questions asked by TA |
| Midterm #1 | 10 % | 3 Questions | Material Covered Week 1-3 |
| Midterm #2 | 15 % | 3 Questions | Material covered week 4-7 |
| Final Exam | 50 % | 6 Questions | Some questions will be based on lab work |

i. Two quizes will be given throughout the term. **If you miss a quiz without a medical excuse there will be no makeup.**

ii. **In order to pass the course, students must pass both the laboratory and exam course portions. Students must obtain a grade of 50% or higher on the exam portion of the course in order for the laboratory write-up portion of the course to count towards the final grade. Students must attend and complete all laboratories. If a laboratory is missed due to illness or other extenuating circumstance, arrangements must be made with the teaching assistant to complete a make-up lab.**

# Communication

Communication is through (i) Newsgroup, (ii) Email, and Web page.

# Academic Misconduct

Please refer to the regulations outlined in the student handbook regarding academic misconduct. The policy for this course is zero tolerance for any form of academic misconduct. Further, **late lab reports will not be graded!!**

# Safety

To ensure your safety and the safety of others, please abide by the lab safety regulations. The lab coordinator will explain them to you during the first lab session.

# Disclaimer

The instructor reserves the right to change any or all of the above in the event of appropriate circumstance, subject to University of Guelph Academic Regulations.

# Course Road-map

ENG241 "Digital Design" will teach you how to specify, design, and implement digital hardware. It will expose you to the basic concepts, representations, models, methods, techniques, standard components and plans. It will also provide you with the required foundations in discrete mathematics. Three principle classes of digital circuits will be discussed: combinational, synchronous sequential and asynchronous.