

ELEC2141: Digital Circuit Design

COURSE INTRODUCTION – Session 1, 2009

1. Course Staff

Academic in charge:	Dr. Ray Eaton	Room EE 207	r.eaton@unsw.edu.au
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Consultations

Consultation time for this subject will be on Tuesdays 15 - 17 in the lecturer's office, room EE 404. Students may also seek consultation with the lecturer at other times by appointment.

Students are encouraged to post questions related to the course syllabus on the WebCT discussion boards. Such questions will be addressed by the lecturer, other course staff and fellow students.

2. Course Details

Credits

ELEC2141 is a 6 UoC course; expected workload is 10-12 hours per week throughout the 12 week session.

Contact Hours

The course consists of 3 hours of lectures, 1 hour of tutorials and 2 hours of laboratory sessions each week.

Lectures:	Tuesday	10 - 12	CLB 6	
	<i>and</i> Wednesday	13 - 14	CLB 6	
Tutorial:	Tuesday	13 - 14	Quad G31	
	Wednesday	17 - 18	Quad G35	
	Thursday	11 - 12	Quad G35	
Laboratory:	Tuesday	12 - 14	EE 233	CT, TW
	Tuesday	14 - 16	EE 233	CT, CR
	Tuesday	16 - 18	EE 233	CR, TW
	Wednesday	09 - 11	EE 233	CJW, CLW
	Wednesday	14 - 16	EE 233	CLW, TW
	Thursday	09 - 11	EE 233	CJW, CT
	Thursday	11 - 13	EE 233	CJW

Tutorial classes start in Week 2. Laboratory sessions start in Week 3.

3. Course Information

Context and Aims

Digital systems are an integral part of many areas of engineering and technology such as personal computers, digital signal processing, telecommunications, speech analysis and recognition and control systems. The objectives of this course are to provide students with the necessary fundamental skills to design and analyze digital circuits in the real world. At the completion of the course, students should be in a position to be able to design and build reliable and cost-effective digital systems.

Aims

The course aims to provide students with fundamental knowledge of digital systems with respect to several different levels of abstraction – from a low-level dealing with electrical circuits through to a high-level dealing with software tools and hardware description languages.

4. Relation to Other Courses

The course is a second-year subject in the school of Electrical Engineering and Telecommunications at the University of New South Wales. It is a core subject for students following a BE (Electrical) or (Telecommunications) program.

Pre-requisites

The pre-requisite for this course is ELEC1111: Electrical and Telecommunications Engineering, which introduced basic concept of electrical circuits.

Following Courses

This course is a pre-requisite for ELEC2142: Embedded System Design, in which the digital system design concepts introduced in ELEC2141 will be applied extensively. It is also a pre-requisite for ELEC3106: Electronics, in which low-level analysis and implementation of digital devices are undertaken.

5. Learning Outcomes

The aim of this subject is to provide students with a general understanding and an appreciation of the fundamentals of digital circuits and simple microprocessor design. At the successful completion of this course, students should be able to:

- Design and analyze combinational circuits
- Display a basic understanding of standard digital circuit elements such as multiplexers, decoders, etc.
- Design and optimize simple synchronous sequential circuits
- Understand the fundamentals of the central processing unit (CPU) in a computer
- Demonstrate knowledge in practical aspects of digital circuits and systems, and their use in more complex systems
- Demonstrate some understanding of the various hardware realizations of the basic digital elements
- Demonstrate basic skills in working with computer-aided design tools, including knowing the rudiments of a hardware description language (Verilog)
- Implement simple designs at various levels, from discrete components to programmable logic devices

Graduate Attributes

Graduate attributes are those which the University and the Faculty of Engineering agree students should develop during their degree. This course aims to aid students in attaining the following attributes:

- *Information literacy – the skills to appropriately locate, evaluate and use relevant information, which is addressed by tutorial questions and laboratory tasks*
- *The ability to engage in independent and reflective learning, which is addressed by laboratory exercises and DVD-based learning material*

- *The capacity for enterprise, initiative and creativity*, which is addressed by a design and implementation assignment
- *The capacity for analytical and critical thinking and for creative problem-solving*, which is addressed by tutorial questions, weekly quizzes and the assignment

Further information can be obtained in the document available at: http://learningandteaching.unsw.edu.au/content/userDocs/grad_attributes.pdf.

6. Syllabus

Introduction to digital systems, number systems, binary numbers, base conversion, binary codes. Binary variables, logical operators, logic gates, Boolean functions, Boolean algebra, standard forms, two-level optimization, Karnaugh maps, don't-care conditions, multi-level optimization, high-impedance outputs. Combinational logic design procedures, technology mapping, function blocks, multi-bit variables, encoders, decoders, multiplexers, demultiplexers. Sequential circuits, basic storage elements, latches and flip-flops structures, direct inputs, finite state machines, transition equations, state tables and diagrams, state assignments, logic diagrams, Mealy and Moore models, state minimization. Arithmetic circuits, half and full adders, cascading adders, signed numbers and 2's complements, subtractors. Programmable devices, FPGAs, hardware description languages, Verilog implementations, simulations. Introduction to computer design, datapaths, arithmetic/logic unit (ALU), shifters, instructions set. Integrated circuits (ICs), CMOS technology, CMOS logic gates.

7. Teaching Strategies

The course consists of the following elements: lectures, tutorials, laboratory work, short quizzes and an assignment.

Lectures

The lectures form the core of this subject. Topics presented in lectures will generally be followed by detailed examples to provide students with the real-life applications. Detailed explanations of the topics will be available to students in the form of lecture notes and the prescribed textbook.

Live lectures will be video-recorded and made accessible to students for revision; however, these recordings should not be considered adequate substitutes for attending lectures in person.

Tutorials

The tutorial problems provide students with in-depth quantitative understanding of the topics covered in lectures. Every tutorial session will have a corresponding problem sheet that covers the topics taught

in the previous week's lectures. Students are expected to attempt the tutorial questions before attending the class and raise any problems incurred during the tutorial session.

Laboratory work

During the laboratory sessions, students will be introduced to real-life digital design scenarios. Each week, a new design problem related to the lectured material is presented. Students will be required to step through the problem to a complete solution using the guidelines given per lab exercise. In the first few exercises, work will be done using breadboards and discrete IC components. At a later stage, students will be taught how to use industry-standard design software and will follow similar (although simplified) design procedures used in industry. Students will need to bring their own breadboards, previously used in ELEC1111, to the laboratory. Breadboards will also be offered for sale through the school office for the price of \$15 each.

A broad understanding of the tools utilized in these exercises is highly encouraged and a bonus lab task will be available to students after the successful completion of all other exercises. The bonus task will carry on from the last lab exercise and will be accompanied by minimal guidelines, allowing students to further demonstrate their ability to analyze and resolve issues independently.

Short Quizzes

There will be weekly quizzes throughout the semester. The purpose of the quizzes is to keep students up-to-date with the lecture material and to test basic understanding of the course concepts. Each quiz will consist of several short-answer questions that target specific topics from the previous week's lectures.

The quizzes are delivered through WebCT and will each be made available for a period of one week between every Monday at 9:00am to the following Monday at 9:00am, after which a new quiz will become available.

Assignment

There will be one assignment for this subject due at the end of Week 10. The assignment will state the specifications for a desired design and will ask students to provide a verified implementation as the result. While working towards the complete design, the students will address most of the core topics covered in lectures thus far.

Though generic guidelines will be provided, there will be no one "correct" solution to the assignment. Students will be expected to work independently on their implementation and to be able to justify the unique design choices along the way.

8. Assessment

There are four components of assessment in this course:

Short quizzes:	10%
Assignment:	10%
Laboratory work:	20% (+5% bonus)
Final examination:	60%

Short Quizzes

The weekly quizzes will make up 10% of the overall mark. Each quiz will consist of a number of short questions and will be marked according to the number of correct answers. The quizzes are a mandatory component of the overall assessment and failure to attempt a quiz will result in no marks being given for the quiz. Each quiz will be available for a period of one week and the results per quiz will be published at the end of the period. No late attempts will be permitted. **Satisfactory performance in this component is necessary to pass this subject.**

Assignment

The assignment, which will consist of a design challenge, forms 10% of the overall mark. It will be assessed upon the successful completion of the implementation and the steps taken during the design process. Marks will be weighted towards students' understandings and their ability to justify the design decisions. Specifications will be released at the beginning of Week 8; submissions will close at the end of Week 10. No late submissions will be accepted unless **prior approval** from the lecturer has been granted.

Laboratory work

The laboratory work will contribute to 20% of the overall mark. Each lab exercise will consist of number of checkpoints that will be marked by the lab assessors. Demonstrators will be available to help students with any questions or difficulties.

Upon completion of a checkpoint, students will be required to write down their student and bench numbers on the Laboratory Queue Sheet and wait for the laboratory assessor to mark their work. Students may continue working on subsequent lab tasks while waiting to be assessed. Students will be required to show the working for each checkpoint and answer questions asked by the assessor to demonstrate their understanding of the ideas addressed within each task. Attendance to the allocated weekly lab session is mandatory and a roll will be taken at the beginning of each lab.

There will be 5% bonus marks available for those students who wish to attempt the additional lab task at the completion of all laboratory exercises. The bonus exercise may require a substantial amount of time to complete successfully and students attempting it are expected to work independently as there will be minimal support provided for this task.

Final examination

The final examination will be a 3-hour, closed-book exam dealing with material from the lectures and the supporting laboratory program. It is worth 60% of the overall mark. The questions will be in a similar style to the tutorial exercises.

9. Resources for Students

Prescribed Textbook

The textbook prescribed for this course is:

- M. M. Mano & C. R. Kime, *Logic and Computer Design Fundamentals*, 4th Edition, Prentice Hall, 2008

Students are strongly encouraged to purchase a copy of this book as lectures will follow the book very closely and the book provides detailed explanations for most topics covered in the course. The textbook can also serve as a reference for some of the low-level material covered in ELEC2142: Embedded System Design.

Reference Books

The following textbooks provide alternate coverage of many of the topics discussed in lectures and constitute adequate reference material:

- R. H. Katz & G. Borriello, *Contemporary Logic Design*, 2nd Edition, Prentice Hall, 2005
- M. M. Mano & M. D. Ciletti, *Digital Design*, 4th Edition, Prentice Hall, 2007
- J. F. Wakerly, *Digital Design: Principles and Practices*, 4th Edition, Prentice Hall, 2006

10. Course Schedule

Week	Topic
1	Number Systems
2	Combinational Logic Circuits 1
3	Combinational Logic Circuits 2
4	Combinational Logic Design
5	Sequential Circuit Elements
6	Sequential Circuit Analysis
7	Sequential Circuit Design
8	Verilog HDL
9	Arithmetic Circuits
10	Computer Design Fundamentals 1
11	Computer Design Fundamentals 2
12	CMOS Technology

11. Other Matters

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other peoples work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a serious offence by the University and severe penalties may apply: <http://www.lc.unsw.edu.au/plagiarism/> .

Continual Course Improvement

The course is under constant revision in order to improve the learning outcomes for students. Students are encouraged to forward any positive or negative feedback on the course to the course lecturer or the academic-in-charge.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School policies: <http://scoff.ee.unsw.edu.au/> .