

**ELC 451 (1.0 CU)**  
**COMPUTER ARCHITECTURE & ORGANIZATION**

**Course Information**

**Professor: Orlando Hernandez**

**Fall 2013: MR 10:00AM–11:20AM/AR144**

**Course Description:** Topics in microprocessor design philosophies, data typing and addressing modes, memory management, and virtual memory, multiprocessing, multitasking, and process communications.

**Instructor Information:** Office Location: AR 147A  
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**Office Hours:** Mondays 4:00 PM - 5:20 PM  
Tuesdays 10:00 AM - 11:20 AM  
By appointment (send me email)  
And whenever my office door is open

**Textbook:** *Computer Organization and Design: The Hardware / Software Interface*, Fourth Edition, by David A. Patterson and John L. Hennessy, Morgan Kaufmann Publishers, 2009. ISBN 978-0-12-374493-7

**Prerequisite:** Digital Circuits and Microprocessors (ENG 312)

**Corequisite:** Microcomputer Systems (ELC 343)

**Grading Policy:** Homework 15%  
Homework will be announced for each chapter after the chapter has been covered.  
Mid-Term Exam 35%  
Final Exam 35%  
Miscellaneous 15%

**Tips for Success:** Read the book sections prior to their discussion in class.  
Do as much homework as possible. Attempt to do all the problems, even the ones that have not been assigned.  
Do not be shy about asking questions, either during class or outside of the class.

**College Level Policies:** Attendance Policy: <http://www.tcnj.edu/~recreg/policies/attendance.html>  
Academic Integrity Policy: <http://www.tcnj.edu/~academic/policy/integrity.html>  
Americans with Disabilities Act (ADA) Policy: <http://www.tcnj.edu/~affirm/ada.html>

## Tentative Agenda:

Week	Topics	Reading
1 Monday 8/26	<b>COMPUTER ABSTRACTION AND TECHNOLOGY</b> Hardware and Interface below Your Program Inside and Around the Computer Performance	CHAPTER 1
2 Monday 9/2	<b>INSTRUCTIONS: LANGUAGE OF THE COMPUTER</b> Operations and Operands of the Computer Hardware Representing Instructions in the Computer Logical Operations	CHAPTER 2
3 Monday 9/9	<b>INSTRUCTIONS: LANGUAGE OF THE COMPUTER</b> Instructions for Making Decisions Supporting Procedures in Computer Hardware Communicating with People	
4 Monday 9/16	<b>INSTRUCTIONS: LANGUAGE OF THE COMPUTER</b> MIPS Addressing for 32-Bit immediates and Addresses Translating and Starting a Program How Compilers Optimize	
5 Monday 9/23	<b>ARITHMETIC FOR COMPUTERS</b> Signed and Unsigned Numbers Addition and Subtraction Multiplication and Division Floating Point	CHAPTER 3
6 Monday 9/30	<b>THE PROCESSOR: DATAPATH AND CONTROL</b> Logic Design Review Building a Datapath Simple Implementation Scheme	CHAPTER 4
7 Monday 10/7	<b>REVIEW</b> <b>TEST #1 (MIDTERM)</b>	
8 Monday 10/14	<b>THE PROCESSOR: DATAPATH AND CONTROL</b> Multi-cycle Implementation Exceptions	
9 Monday 10/21	<b>THE PROCESSOR: DATAPATH AND CONTROL</b> Pipelining Pipelined Datapath Pipelined Control	
10 Monday 10/28	<b>THE PROCESSOR: DATAPATH AND CONTROL</b> Data Hazards and Forwarding Data Hazards and Stalls Branch Hazards	

**Tentative Agenda (continued):**

Week	Topics	Reading
11 Monday 11/4	<b>LARGE AND FAST: EXPLOITING MEMORY HIERARCHY</b> Basics of Caches Measuring and Improving Cache Performance Virtual Memory Common Framework for Memory Hierarchies	CHAPTER 5
12 Monday 11/11	<b>STORAGE AND OTHER I/O TOPICS NETWORKS, AND OTHER PERIPHERALS</b> Dependability, Reliability, and Availability Disk and Flash Storage Connecting and Interfacing Processors, Memories, and I/O Analyzing and Designing I/O Systems	CHAPTER 6
13, 14 Monday 11/18 Monday 11/25	<b>MULTICORES, MULTIPROCESSORS, AND CLUSTERS</b>	CHAPTER 7
15 Monday 12/2	<b>REVIEW</b>	
16, 17 Monday 12/9 Monday 12/16	<b>TEST #2 (FINAL)</b>	

## **Educational Objectives**

*(What TCNJ ECE engineers should be able to accomplish during the first few years after graduation)*

- To contribute to the economic development of New Jersey and the nation through the ethical practice of engineering;
- To become successful in their chosen career path, whether it is in the practice of engineering, in advanced studies in engineering or science, or in other complementary disciplines;
- To assume leadership roles in industry or public service through engineering ability;
- To maintain career skills through life-long learning.

## **Electrical and Computer Engineering Student Outcomes**

*(What TCNJ Electrical and Computer Engineering students are expected to know and be able to do at graduation. What knowledge, abilities, tools and skills the program gives the graduates to enable them to accomplish the Educational Objectives)*

The Student Outcomes listed below are expected of all graduates of the Electrical or Computer Engineering Program.

### **ECE graduates will have:**

- an ability to apply knowledge of mathematics, science and engineering;**  
**Binary math used extensively in homework problems and tests.**
- an ability to design and conduct experiments, as well as to analyze and interpret data;
- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;**  
**Students do design in homework problems.**
- an ability to function in multidisciplinary teams;
- an ability to identify, formulate and solve engineering problems;**  
**Students do homework problems.**
- an understanding of professional and ethical responsibility;
- an ability to communicate effectively;**  
**Students do presentations and write reports.**
- the broad education necessary to understand the impact of engineering solutions in a global and societal context;
- a recognition of the need for and an ability to engage in life-long learning;
- a knowledge of contemporary issues;
- an ability to use the techniques, skills and modern engineering tools necessary for engineering practice;**  
**Modern computer design tools are discussed heavily throughout the course.**

## Course Objectives:\*

- Objective 1 To understand system organization (processors, memory and management, I/O interfaces). [a, c, e] [1, 2]
- Objective 2 To understand the various tradeoffs associated with Instruction Set Architectures (instruction formats, expanding op-codes, addressing modes), and learn the tools of microprocessor system design. [a, c, e, k] [1]
- Objective 3 To examine the various CPU controls (hardwired, microsequencer). [a, c, e, g, k] [1, 2]
- Objective 4 To explore cache and virtual memory, and I/O-related topics in relation to microprocessor system design. [a, c, e, k] [1, 2, 4]

## Topics Covered:

1. Digital Logic Review
2. Finite State Machines
3. Instruction Set Architectures
4. Computer Organization
5. Register Transfer Languages, Verilog or VHDL programming
6. CPU Design
7. Microsequencer Control Unit Design
8. Computer Arithmetic, IEEE Floating Point Standards
9. Memory Organization – Physical vs. Cache, Virtual Memory
10. Input/Output Organization

## Evaluation:

- A. Examinations
- B. Project Assignments
- C. Homework

## Performance Criteria:\*\*

- Objective 1 Students will learn how to program in a hardware description language. [B, C]
- Objective 2 Students will author the major components of a microprocessor. [B, C]
- Objective 3 Students will be able to apply digital design principles to machine design. [A, B, C]
- Objective 4 Students will apply reasoning techniques to the solution of a micro-system design problem. [A, B, C]

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\* Small letters in brackets refer to the Student Outcomes

\*\* Capital letters in brackets refer to the evaluation methods used to assess student performance

## ELC 451: ADDITIONAL INFORMATION

### 1. DESCRIPTION OF DESIGN ACTIVITY

N/A

### 2. ENGINEERING STANDARDS

ASCII code and IEEE floating point.

### 3. REALISTIC CONSTRAINTS

**Economic:** The cost reduction impact of Very Large Scale Integration (VLSI) semiconductor circuits in the price and performance of modern computers is covered in this course.

**Environmental:** The impact of smaller and more powerful computers that require less electrical power is discussed in light of the environmental benefits of electronic equipment that requires less energy and less physical space.

**Sustainability:** Different models for implementing computer control are discussed. These are hardwired and micro-programmed. The different sustainability levels for these models are discussed.

**Ethical:** Computer security is discussed in this course.

**Social Impact:** The impact that computers have had in society is discussed: new computer related laws, computer piracy, hacking, computer crimes, as well as the benefits of computers for society in terms of how society works, learns, and is entertained in entirely new ways that did not exist before the advent of computers.

### 4. MODERN AND PROFESSIONAL ENGINEERING TOOLS USAGE

N/A

### 5. COMPUTER USAGE

Students use computers during to prepare reports on reading assignments.

### 6. FEEDBACK MECHANISMS

**Examinations:** Students are given a mid-term examination and a final one.

**Reports:** Students are graded on reports, which include not only the technical aspects, but also the level of communication skills. There are at least three assignments.

**Homework:** Homework problems are assigned and graded. Not all the problems are graded. These are selected randomly, but students do not know in advanced which problems are going to be graded, so they are behooved to do all assigned problems. These problems are a mixture of analysis and design problems.