

# ***CS-350: Computer Organization, Spring 2003 Semester***

## **Course Syllabus**

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### **Summary Course Description:**

This course provides a solid theoretical foundation that provides insight into the innermost workings of the modern digital computer, together with a thorough understanding of the organization and architecture of real computers. Students learn how a digital computer works through thorough study of the principles of operation of logic circuits of progressively increasing complexity. Number systems and various schemes for the digital representation of numbers are also discussed, as well as the principles of digital integer arithmetic, to provide insight into several different ways that arithmetic calculations can be made in digital computers.

The principal subsystems of a modern digital computer are surveyed, including the Central Processing Unit (CPU), system bus and subsidiary buses, primary storage (RAM and ROM), including both main memory and cache memory, secondary storage (Hard Disk Drive (HDD) and floppy drives, CD-ROM and DVD-ROM drives), input/output ports, and several types of input/output devices, including keyboard and video display terminal.

Basic electronics is reviewed, in order to convey an understanding of the operation of the fundamental logic circuits (AND gates, OR gates, NOT gates, buffer gates, XOR gates and XNOR gates) that constitute the building blocks for higher-level logic, and some more complex digital integrated circuits. The types of integrated circuits that are studied include simple combinational logic, such as latches, flip-flops, and registers, combinational logic of intermediate complexity, including multiplexors, demultiplexors, encoders and decoders, and several examples of more highly complex integrated circuits, such as an Arithmetic Logic Unit (ALU), a simple bus, “Random Access Memory” (RAM) and “Read-Only Memory” (ROM) modules.

Computer operations are introduced, along with the representation of computer operations in an Assembly Language. Implementation of program statements in a Higher Level Language, such as C or C++, is studied through the decomposition of each higher-level language statement into a sequence of machine or Assembly-Language instructions, and some of these are further decomposed into sequences of micro-operations. The operation of major subsystems of

the computer is examined through decomposition of a subsystem into an organized set of simpler circuit elements.

Additional critical subjects covered include the principles of hierarchical computer organization, machine instruction sets, addressing modes, CISC vs. RISC, input/output processing, and interrupt handling, as well as the application of many of these concepts to modern personal computers, and the boot process.

## Required Textbooks and Materials:

### **Main Course Textbook (REQUIRED):**

- (1) CARPINELLI, JOHN D. (2001). *Computer System Organization and Architecture*. Boston, MA: Addison-Wesley Longman. QA76.9.C643 C37 2002; 004.2'2—dc21; 00-055836; ISBN 0-201-612534. Web-site support for this text is to be found at: [http://occawlonline.pearsoned.com/bookbind/pubbooks/carpinelli\\_awl/](http://occawlonline.pearsoned.com/bookbind/pubbooks/carpinelli_awl/)

### **RECOMMENDED:**

- (2) MAXFIELD, CLIVE RICHARD (1995). *Bebop to the Boolean Boogie. An Unconventional Guide to Electronics Fundamentals, Components, and Processes*. Solana Beach, CA: HighText Publications. TK7868.D5M323 1995; 821.39'5—dc20; 94-41062; ISBN 1-878707-22-1. [This is a very readable book that provides further details on design and construction of computer chips and circuit boards. Recommended for students in the upper 25% of the class only, who may be able to find the time to enjoy the enrichment that it provides without compromising their ability to master the required course material.]

## Suggested Supplementary Materials:

**Grammar and Writing:**

- (3) GORDON, KAREN ELIZABETH (1993). *The Deluxe Transitive Vampire: The Ultimate Handbook of Grammar for the Innocent, the Eager, and the Doomed*. New York, NY: Pantheon Books. ISBN: 0679418601. [This book is a concise, wittily written tutorial on the fine points of grammar and punctuation.]
- (4) DUPRE, LYN (1998). *Bugs in Writing Revised. A Guide to Debugging Your Prose*. Reading, MA: Addison-Wesley. ISBN: 0-201 37921-X. [The author specifically addresses the needs of computer professionals and other technical people to write clearly.]
- (5) STRUNK, WILLIAM, JR.; & White, E.B. (2000). *The Elements of Style. With Revisions, an Introduction, and a Chapter on Writing. Fourth Edition*. New York, NY: Longman. PE1408.S772 1999; 808'.042—dc21; 99-16419; ISBN 0-205-30902-X (paperback) or 0-205-31342-6 (casebound). [A classic on clarity in writing.]

**Architecture & Maintenance of the “Wintel” PC (select one only):**

**NOTE:** Our recent experience in the Computer Science Department is that the majority of students registered in CS-350 are already experienced in the installation of new circuit boards and other components in a PC, in the removal of old and outdated circuit boards and components, and in the selection of a complete set of components to constitute a PC as well as in their assembly into a working computer. If you are one of the majority already experienced and knowledgeable in the assembly and disassembly of PCs, then you do not need to purchase one of the books listed below. However, if you are not in this category, then it is strongly recommended that you invest in one of the books listed below, and study it on your own.

- (6) ANDREWS, JEAN (2002). *Enhanced A+ Guide to Managing and Maintaining Your PC — . Third Edition Comprehensive. With Windows XP Guide*. Cambridge, MA: Course Technology. ISBN 0-619-130628.
- (7) MESSMER, HANS-PETER (2001). *The Indispensable PC Hardware Book. Fourth Edition*. Boston, MA: Addison-Wesley Professional. ISBN 0-201-59616-4. List Price: \$49.99, available as of 06 Dec 2002 from Amazon.com for \$34.99 + shipping: [www.barnesandnoble.com](http://www.barnesandnoble.com) or [www.amazon.com](http://www.amazon.com).
- (8) MINASI, MARK (2001). *The Complete PC Upgrade and Maintenance Guide. Twelfth Edition*. Alameda, CA: Sybex, Inc. TK7887.M56 2001; ISBN 0782129900. List Price: \$59.99 (hardcover), available as of 06 Dec 2002 from Amazon.com for \$41.99 + shipping: [www.barnesandnoble.com](http://www.barnesandnoble.com) or [www.amazon.com](http://www.amazon.com).

- (9) MUELLER, SCOTT (2002). *Upgrading and Repairing PCs. Fourteenth Edition.* Que Corporation. TK7887.5.M84 2002; ISBN 0789727455. List Price \$59.99 (hardcover), available as of 06 Dec 2002 from Amazon.com for \$41.99 + shipping: [www.barnesandnoble.com](http://www.barnesandnoble.com) or [www.amazon.com](http://www.amazon.com).
- (10) NORTON, PETER C.; & CLARK, SCOTT (2002). *Peter Norton's New Inside the PC. First Edition.* Indianapolis, IN: Sams Publishing Co. QA76.8.I2594.N67 2002; ISBN 0672322897. List Price \$39.99 (paperback), available as of 06 Dec 2002 from Amazon.com for \$27.99 + shipping: [www.barnesandnoble.com](http://www.barnesandnoble.com) or [www.amazon.com](http://www.amazon.com).

**Here's one that's a bit off the beaten track:**

- (11) CAMARDA, BILL (1998). *Cheapskate's Guide to Bargain Computing.* Upper Saddle River, NJ: Prentice-Hall PTR. QA76.5.C346 1998; 004.16'029'7--dc21; 97-26393; ISBN 0-13-756404-X. Price \$34.95

**Useful Software:**

- (12) PowerQuest Corporation's PARTITIONMAGIC software, version 8.0. URL for product information: <http://www.powerquest.com/partitionmagic/>

## Learning Objectives:

By the end of this course, the student should:

- (1) understand the operational characteristics of computer hardware, including basic machine subsystems and their principal components;
- (2) understand the principles of positional number representation, and be able to convert a number represented in any possible radix to the equivalent number represented in any other radix;

- (3) understand the difference between information and its representation on a machine, and be able to interpret a sequence of bits differently according to whether it represents an integer in any of several different representational schemes, a text character, a machine instruction, a memory address, etc.;
- (4) understand how data are moved around and manipulated inside a computer, and also inside representative major subsystems, and be able to describe the operation of the machine in terms both of machine language instructions and micro-operations;
- (5) understand the operation both of floppy disk drives and of hard drives, be able to explain how a disk is organized to hold data, and be able to install or replace a disk drive in a PC;
- (6) understand how memory is organized in a modern digital computer, be able to explain the memory map of a PC, and be able to ascertain the memory configuration of a PC and replace/reconfigure the memory as needed;
- (7) understand the principles of integer computer arithmetic, and be able to specify what would be the register contents and status flag conditions resulting from addition or subtraction of two numbers using the rules of unsigned numbers, signed-magnitude numbers, ones' complement and two's complement numbers, and saturation arithmetic;
- (8) understand the basic principles of machine operations, addressing modes, and assembly language, and be able to write a simple assembly language program that could be used to implement a single instruction in a higher-level-language program, making use of one or more of the addressing modes of the assembler;
- (9) understand the sequence of steps that takes place when a computer is booted up, and be able to partition a hard disk drive and install an alternative operating system, so that at boot-up time one of the operating systems installed on the machine can be selected to run.

## **Instructors:**

[Dr. Elizabeth Adams](#) (section 3)

[Dr. Charles Abzug](#) (sections 1 and 2)

## **Course Coverage:**

1. Integer numbers and their representation (positional number systems)
  - a. Decimal Numbers
  - b. General Number Representation: the Radix
  - c. Binary Numbers
  - d. Octal Numbers
  - e. Hexadecimal Numbers
  - f. Interconversion among Number Representations
    - i. Other radices to decimal
    - ii. Decimal to other radices
    - iii. Binary to Octal and Octal to Binary
    - iv. Binary to Hexadecimal and Hexadecimal to Binary
2. Logic Circuits
  - (a) Individual Logic Gates:
    - (i) NOT
    - (ii) Buffer
    - (iii) AND and NAND
    - (iv) OR and NOR
    - (v) XOR (odd function)
    - (vi) XNOR (even function)
  - (a) Simple Logic Circuits: Small-Scale Integration (SSI)
  - (b) Complex Logic Circuits: Medium-Scale Integration (MSI)
3. Basic Electronics
4. Principal Elements of a Computer
  - a. Central Processing Unit (CPU) or Microprocessor
  - b. Bus
    - i. Power Bus
    - ii. Data Bus
    - iii. Address Bus
    - iv. Control Bus
  - c. Memory
    - i. Rewritable Memory (“Random Access Memory”, or RAM)
    - ii. Not-Readily-Rewritable Memory (“Read-Only Memory”, or ROM)
      - (1) simple ROM
      - (2) Programmable “Read-Only Memory” (PROM)
      - (3) Erasable Programmable “Read-Only Memory” (EPROM)
      - (4) Electrically Erasable Programmable “Read-Only Memory” (EEPROM), also known as “flash memory”
    - iii. Memory Size
    - iv. Memory Addressing
    - v. The Memory Map

- vi. Direct Memory Access (DMA)
  - d. Input and Output, and Data Storage:
    - i. HDD (Hard Disk Drive)
    - ii. Floppy Disk
    - iii. "ZIP", "JAZ", etc.
    - iv. CD-ROM
5. Computer Operations
- a. What does a bit sequence represent?
    - i. Instruction
    - ii. Address in memory or elsewhere
    - iii. Data
      - (a) Number: Multiple schemes for representing binary numbers
        - (1) Unsigned Integer
        - (2) Signed-Magnitude
        - (3) Ones' Complement
        - (4) Two's Complement
      - (b) Text
      - (c) Other forms of data
  - b. Controlling the computer
6. Integer Arithmetic
- a. Understanding Decimal Addition and Subtraction
  - b. Addition and Subtraction in Binary
  - c. Integer Arithmetic in Digital Computers
    - (i) Limitation in the Number of Bits Represented
    - (ii) Addition and Subtraction using each representation
      - (5) Unsigned Integer Arithmetic
      - (6) Signed-Magnitude Arithmetic
      - (7) Ones' Complement Arithmetic
      - (8) Two's Complement Arithmetic
      - (9) Saturation Arithmetic
7. Writing and storing programs, retrieving programs from storage, and running programs
- a. Source Code
  - b. Object Code
8. Understanding the CPU
- a. Accumulator
  - b. Basic Addressing Modes: Implied, Immediate, and Indirect
  - c. Status Flags
  - d. Basic Arithmetic-Logic Unit (ALU)
  - e. Arithmetic Instructions

- f. Shifter/Rotator
  - g. Internal Communications Paths
  - h. Instruction Register
  - i. Control Logic
  - j. Program Counter and Auxiliary Program Counters
  - k. Simple Control Instructions:
    - i. Unconditional Jump
    - ii. Conditional Jumps
  - l. Intermediate Addressing Modes:
    - i. Indirect
    - ii. Indexed
    - iii. Autoincrement and Autodecrement Indexed Addressing
      - (1) Pre-indexed
      - (2) Post-indexed
  - m. Stack and Stack Pointer
  - n. Intermediate Control Instructions
    - a. Jump to Subroutine
    - b. Return from Subroutine
  - o. Interrupt Vector
9. Input and Output
- a. Numeric Keypad and Display
  - b. Keyboard
10. Simple Video Display
11. Basics of Assembly Language

## [Course Practices.](#)

## [Grading Policy.](#)

## [Homework.](#)

## [Philosophy Regarding Classes Missed by Students.](#)



## **Class Meetings:**

Classes meet during the Spring 2003 semester on Monday, Wednesday, and Friday mornings in ISAT/CS Room 243 from 0905 to 0955 hrs (Section 1) and from 1010 to 1100 hrs (Section 2), or in ISAT/CS Room 350 on Mondays and Wednesdays from 1700 to 1815 hrs (Section 3).