HARDWARE CORE SYLLABUS

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INTRODUCTION

This syllabus is organized around the view of digital computer systems presented in chapter 1 of Bell and Newell: the major divisions of the syllabus correspond to the major conceptual levels of design and description of digital systems, and the divisions (levels) appear in order of increasing complexity. Two things need to be said about this organization.

First, while this conceptual structure of computer systems according to levels of complexity has an intrinsic formal appeal, many if not most of the references cited at any given level or sublevel of the structure do not confine themselves exclusively to material at that level. References occasionally reach up to borrow concepts from a higher level of complexity, and of course they frequently reach down to provide lower-level underpinnings for the systems they describe.

Second, the order of presentation in the syllabus is probably not the best from the pedagogical point of view. It is certainly not the case that references strongly depend on previously-cited references throughout. In fact, some "reverse" dependence probably exists. In particular, readings at the Electronic Circuits Level could wisely be postponed until after Switching Circuits are introduced.

Four books are heavily used here: Bell, Grason, and Newell (1972), Bell and Newell (1971), Hill and Peterson (1968), and Hill and Peterson (1973).

Hill and Peterson (1973), ch. 1
Bell and Newell, ch. 1

I. ELECTRONIC CIRCUITS LEVEL

Though it is clearly fundamental to computer systems, the Electronic Circuits Level is the least important of the digital systems levels in the hardware core. The most primitive design primitives, from the point of view of the core, are not transistors, resistors, and capacitors; but rather, logic gates. A broad understanding of circuit technology, rather than an ability to design gates from electronic primitives, is called for at this level.

Realization of logic design primitives from electronic components
- Hill and Peterson (1968), ch. 5
- Hill and Peterson (1973), ch. 3, pp. 37-50

Logic families and circuit technology
- Garrett (skim only)
- Hittinger

II. LOGIC DESIGN LEVEL

A. Switching Circuits Sublevel

The area of combinational and sequential switching circuits is perhaps the best-studied facet of computer systems design. Techniques of representation, analysis, and synthesis are well understood and widely published. Hill and Peterson (1968) is one of many adequate sources for most of this material. Millman and Halkias (1972) describes some actual integrated circuits which implement combinational and sequential logic functions.

1. Combinational Circuits

Truth functions, Boolean algebra, circuit simplification
Hill and Peterson (1968), ch. 3, 4, 6

Codes
Hill and Peterson (1968), ch. 8

Reliability, fault detection, redundancy
Kohavi, ch. 8

Combinational integrated circuits
Millman and Halkias, ch. 17, pp. 593-623

Design examples
Dietmeyer, ch. 2, pp. 198-216
Hill and Peterson (1973), ch. 11

2. Sequential Circuits

Introduction
Hill and Peterson (1968), ch. 9

Clocked sequential circuits
Hill and Peterson (1968), ch. 10

Sequential integrated circuits
Millman and Halkias, ch. 17, pp. 624-647

Races, hazards, glitches
Hill and Peterson (1968), ch. 13, pp. 322-325, 332-339
Chaney and Molnar

B. Register Transfer Sublevel

In contrast to the Switching Circuits Sublevel of the digital systems hierarchy, the Register Transfer Sublevel is (at least formally) relatively new and not thoroughly studied. The book by Bell, Grason, and Newell attempts to define and analyze RT level design as a discipline in its own right, and is the principal text for this material. While Hill and Peterson (1973) does not admit a formal RT design level as such, its careful design of a small processor (ch. 2, 5, 6, 7) can easily be viewed at this level. Microprogramming, a very important topic, is listed last because it probably staddles the Logic Design and Programming Levels.

Introduction
Bell, Grason, and Newell, Preface, ch. 1
Hill and Peterson (1973), ch. 4

Number representation, arithmetic
Stone, ch. 2, pp. 27-40

Module sets

Macromodules
Clark
Ornstein, et. al.
Clark and Molnar

DEC RTM's
Bell, Grason, and Newell, ch. 2

Comparison of module sets
Ellis and Franklin

RTM design examples
Bell, Grason, and Newell, ch. 3

RTM design issues and performance analysis
Bell, Grason, and Newell, ch. 4

Processor and computer design examples
Bell, Grason, and Newell, ch. 6
Hill and Peterson (1973), ch. 2, 5, 6, 7

Microprogramming
Wilkes and Stringer (Bell and Newell, ch. 28)
Hill and Peterson (1973), ch. 8
Rosin

III. PROGRAMMING LEVEL

The Programming Level of the digital systems hierarchy is more a level of hardware description than of hardware construction. The salient subject at this level is the comparative study of the instruction sets (ISP's) of various computers. (The Table of Contents of Bell and Newell provides a useful map.) The important topic of computer Input/Output has been given a separate heading, but of course the machine descriptions cited below all contain information on their own I/O methods. While proficiency in machine language programming for each of these computers is obviously unnecessary from the point of view of the hardware core, gaining a general knowledge of the ISP of two or three machines is probably a good idea.

ISP and PMS notations
 Bell and Newell, ch. 2, Appendix

Minicomputers

DEC PDP-8
 Bell and Newell, ch. 5

Data General Nova
 How to Use the Nova, ch. I, II

DEC PDP-11
 PDP-11 Processor Handbook, Part I, ch. 1-4

Large computers

IBM 7094
 Bell and Newell, ch. 41

IBM 360
 Blaauw and Brooks (Bell and Newell, ch. 43)
 Stevens (Bell and Newell, ch. 44)

DEC PDP-10
 DECsystem-10 Assembly Language Handbook, pp. 3-196

Language-influenced computers

Burroughs B5000
 Lonergan and King (Bell and Newell, ch. 22)

EULER machine
 Weber (Bell and Newell, ch. 32)

Input/Output, communications
 Hill and Peterson (1973), ch. 9, 10
 PDP-11 Peripherals and Interfacing Handbook, Part II, ch. 1

IV. PMS LEVEL

Computers were considered at the Programming Level as instruction-executing devices, and their instruction sets were of key importance. At the PMS Level, computers are considered to be information-processing structures; details of their programs are suppressed, and their top-level organization and behavior dominate their description and analysis. Computer memories of various types, essential PMS components, have been neglected thus far in the syllabus, and so are here considered in more detail than, say, processors.

The computer space
Bell and Newell, ch. 3

Memory

Memory devices
Hill and Peterson (1973), ch. 3, pp. 50-76

Virtual memory
Denning

Cache memory
Liptay

Discussions of large, fast, parallel computers
Hill and Peterson (1973), ch. 14
Lehman (Bell and Newell, ch. 37)
Flynn

High performance computers

IBM Stretch
Bloch (Bell and Newell, ch. 34)

IBM 360/91
Flynn and Low
Anderson, et. al.

CDC 6600
Thornton (Bell and Newell, ch. 39)

ILLIAC IV
Barnes, et. al. (Bell and Newell, ch. 27)
Bouknight, et. al.

C.mmp
Wulf and Bell

Analysis of a computer family
Bell and Newell, introduction to Section 3 of Part 6

Computer networks
Bell and Newell, ch. 40
Heart, et. al.

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