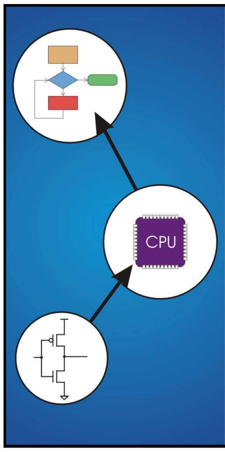

CS270
Computer Organization

Lecture Goals

Review course logistics
- Assignments & quizzes
- Policies
- Organization
- Grading Criteria

Introduce key concepts
- Role of Abstraction
- Software versus Hardware
- Universal Computing Devices
- Layered Model of Computing

2

Logistics

Lectures: See syllabus
Staff: See syllabus
Recitations: See syllabus
Help desks: See syllabus
Office hours: See syllabus
Materials on the website:
- http://www.cs.colostate.edu/~cs270

- **Piazza: access through Canvas, or directly**

3

Assignments & Quizzes

Assignments

- Posted on Progress page of the course website
- Programming (C, LC-3) or Logisim circuit designs
- See Canvas for due dates
- Submit via Checkin before 11:59 PM (unless otherwise specified).
- Late period for assignments – posted in assignment, 20% deduction
- Regrading requests in Piazza (see the syllabus for policies).

Quizzes:

- Can be on-line (canvas) or in-class (using iClicker)

4

Policies

Grading Criteria

- Assignments (20%)
- Recitations (10%)
- Quizzes and iClicker (10%)
- Two Midterm Exams (20% each)
- Final Exam (20%)

Late Policy

- None accepted

Academic Integrity

- http://www.cs.colostate.edu/~info/student-info.html
- Do your own work
- Cannot copy and paste *any* code, unless provided by us

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People

Instructor:

- Phil Sharp

Graduate Teaching assistants:

- N/A

Undergraduate Teaching Assistants:

- Kacey Schulz

Office hours/locations

- See course website

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Organization

1/3 C programming: data types, language syntax, variables and operators, control structures, functions, pointers and arrays, memory model, recursion, I/O, data structures
1/3 Instruction set architecture: machine/assembly code, instruction formats, branching and control, LC-3 programming, subroutines, memory model (stack)
1/3 computer hardware: numbers and bits, transistors, gates, digital logic, state machines, von Neumann model, instruction sets, LC-3 architecture

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Top Down Perspective

- **Multilayered view:**
  - **Higher layers serves as the specification.**
  - **Lower layer implements provides the implementation**
- **We will see**
  - **How a higher level language (C) is implemented by a processor instruction-set architecture (ISA), LC-3 in our case ?**
  - **How an ISA is implemented using digital circuits?**
  - **How are digital circuits implemented using transistors?**
  - **And so on …**

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Grading Criteria

Letter Grade	Points
A	≥90%
B	≥80%
C	≥70%
D	≥60%

- **We will not cut higher than this, but we may cut lower.**
- **Your average score on exams must be ≥65% to receive a passing grade in this course.**

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How to be successful in this class

1) Read the textbook.
2) Attend all classes and recitations.
3) Take the in-class and on-line quizzes as required.
4) Do the worksheets.
5) Do all the assignments yourself,
   - ask questions (early! (but not *too* early!)) if you run into trouble.
6) Take advantage of lab sessions where help is available from TAs,
   - but try to do it yourself first, too much help can be harmful.

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Text book:
Introduction to Computing Systems:
From Bits and Gates to C and Beyond
2nd Edition

Yale N. Patt and Sanjay J. Patel

Slides based on G. T. Byrd, NCState, © McGraw-Hill,
With modifications/additions by CSU Faculty

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Other resources:

- Computer Organization and Design by David Patterson, John Hennessy
- Introduction to the Theory of Computation by Michael Sipser
- C Programming Language by Dennis Ritchie, Brian Kernighan
- MIT Open Courseware 6.004

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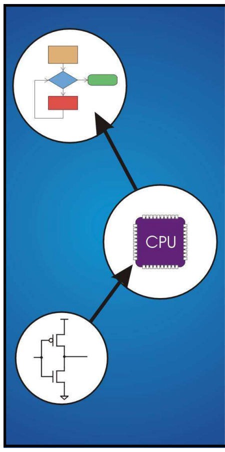


Chapter 1
Welcome Aboard

Two Recurring Themes

Abstraction

- Productivity enhancer – don't need to worry about details…
  Can drive a car without knowing how
  the internal combustion engine works.
- …until something goes wrong!
  Where's the dipstick? What's a spark plug?
- Important to understand the components and how they work together.

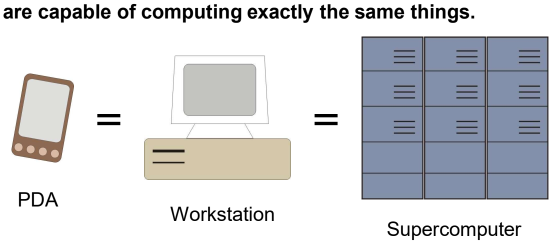
Hardware vs. Software

- It's not either/or – both are components of a computer system.
- Even if you specialize in one,
  you should understand capabilities and limitations of both.

1-14

Big Idea #1: Universal Computing Device

All computers, given enough time and memory, are capable of computing exactly the same things.



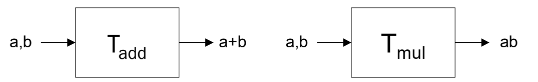
1-15

Turing Machine

Mathematical model of a device that can perform any computation – Alan Turing (1937)

- **ability to read/write symbols on an infinite "tape"**
- **state transitions, based on current state and symbol**

Every computation can be performed by some Turing machine. ***(Turing's thesis)***



Turing machine that adds *Turing machine that multiplies*

For more info about Turing machines, see http://www.wikipedia.org/wiki/Turing_machine/

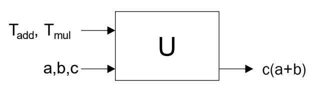
For more about Alan Turing, see http://www.turing.org.uk/turing/

1-16

Universal Turing Machine

A machine that can implement all Turing machines -- this is also a Turing machine!

- **inputs: data, plus a description of computation (other TMs)**



Universal Turing Machine

U is <u>programmable</u> – so is a computer!

- **instructions are part of the input data**
- **a computer can emulate a Universal Turing Machine**

A computer is a universal computing device.

1-17

From Theory to Practice

In theory, computer can *compute* anything that's possible to compute

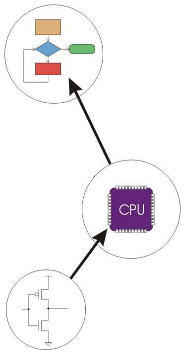
- **given enough *memory* and *time***

In practice, *solving problems* involves computing under constraints.

- **time**
  - **weather forecast, next frame of animation, ...**
- **cost**
  - **cell phone, automotive engine controller, ...**
- **power**
  - **cell phone, handheld video game, ...**

1-18

Big Idea #2: Transformations Between Layers



Problems

Algorithms

Language

Instruction Set Architecture

Microarchitecture

Digital Circuits

Devices

1-19

How do we solve a problem using a computer?

A systematic sequence of transformations between layers of abstraction.

Problem

Software Design:
choose algorithms and data structures

Algorithm

Programming:
use language to express design

Program

Compiling/Interpreting:
convert language to machine instructions

Instr Set Architecture

1-20

Deeper and Deeper…

Instr Set Architecture

Processor Design:
choose structures to implement ISA

Microarch

Logic/Circuit Design:
gates and low-level circuits to implement components

DigCircuits

Process Engineering & Fabrication:
develop and manufacture lowest-level components

Devices

1-21

Descriptions of Each Level

Problem Statement
- stated using "natural language"
- may be ambiguous, imprecise

Algorithm
- step-by-step procedure, guaranteed to finish
- definiteness, effective computability, finiteness

Program
- express the algorithm using a computer language
- high-level language, low-level language

Instruction Set Architecture (ISA)
- specifies the set of instructions the processor (CPU) can perform
- data types, addressing mode

1-22

Descriptions of Each Level (cont.)

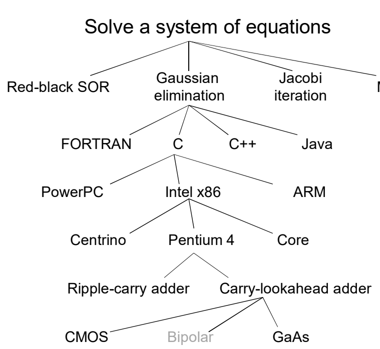
Microarchitecture
- detailed organization of a processor implementation
- different implementations of a single ISA

Logic Circuits
- combine basic operations to realize microarchitecture
- many different ways to implement a single function (e.g., addition)

Devices
- properties of materials, manufacturability

1-23

Many Choices at Each Level



Tradeoffs:
cost
performance
power
(etc.)

1-24

Course Outline

Bits and Bytes
- How do we represent information using electrical signals?

C Programming
- How do we write programs in C?
- How do we implement high-level programming constructs?

Instruction set architecture/Assembly language
- What operations (instructions) will we implement?
- How do we use processor instructions to implement algorithms?
- How do we write modular, reusable code? (subroutines)
- I/O, Traps, and Interrupts: How does processor communicate with outside world?

Digital Logic and processor architecture
- How do we build circuits to process and store information?
- How do we build a processor out of logic elements?

Computer systems: what is next?

1-25

Questions

High level language advantages?

Low level language advantages?

Difference between ISA and Microarchitecture?

1-26