

# Introduction to Computing Systems: From Bits and Gates to C and Beyond 2<sup>nd</sup> Edition

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Original slides from Gregory Byrd, North Carolina State University  
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## Lecture Goals

- Review course logistics
  - Assignments
  - Policies
  - Organization
  - Grading Criteria
- Introduce key concepts
  - Role of Abstraction
  - Software versus Hardware
  - Universal Computing Devices
  - Layered Model of Computing

## 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

## Assignments

Assignments are posted on website:

- Weekly assignments (mostly) alternate between written and programming assignments.
- Homework assignments: submission mode and deadline varies.
- Programming assignments are submitted in electronic form Sun. at 10pm.
- Late submission varies depending on the difficulty of the assignment.
- Regrading: through Piazza (see syllabus).

## Policies

- Grading Criteria
  - Assignments (35%)
  - Recitations (10%)
  - Peer Instruction (5%)
  - Two Midterm Exams (15% each)
  - Final Exam (20%)
- Late Policy
  - On-time = full points, late submission= 20% penalty
- Academic Integrity
  - <http://www.cs.colostate.edu/~info/student-info.html>
  - Do your own work
  - Be smart about Internet resources

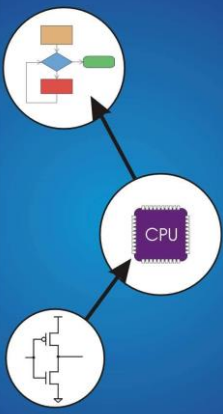
## Organization

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

## Grading Criteria

How to be successful in this class:

- 1) Attend all classes and recitations, info will be presented that you can't get anywhere else.
- 2) Do all the homework assignments, ask questions (early! (but not *too* early!)) if you run into trouble.
- 3) Take advantage of lab sessions where help is available from instructors.
- 4) Read the textbook, work through the end of chapter problems.



The diagram on the left side of the slide features a blue background. At the top left, there is a circular icon containing a logic gate (a diamond shape with a green bar on top and a red bar on the bottom). An arrow points from this icon to a central circular icon containing a purple CPU chip with the letters 'CPU' on it. Below the CPU icon is another circular icon containing a transistor symbol. To the right of this diagram, the text 'Chapter 1 Welcome Aboard' is displayed in a large, bold, black font.

## Chapter 1 Welcome Aboard

## Introduction to the World of Computing

- Computer: electronic genius?
  - NO! **Electronic idiot!**
  - Does exactly what we tell it to, nothing more.
- Goal of the course:
  - You will be able to write programs in C
  - You will understand how a computer works (what's going on under the hood).
- Textbook Approach:
  - From the bottom up (we will use mostly a top-down approach).
  - **Bits → Transistors → Gates → Logic → Processor → Instructions → Assembly Code → C Programming**

## Two Recurring Themes

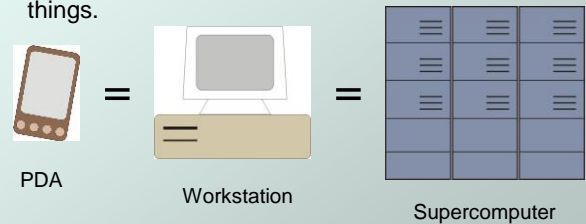
- **Abstraction**
  - Productivity enhancer – don't need to worry about details...
    - Can drive a car without knowing how the internal combustion engine works.
  - ...until something goes wrong!
    - Where's the dipstick?
    - What's a spark plug?
  - Important to understand the components and how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

## Two Recurring Themes

- **Hardware vs. Software**
  - It's not either/or – both are components of a computer system that cooperate.
  - Even if you specialize in one, you should understand capabilities and limitations of both.
  - The best programmers understand the computer systems which run their programs.
  - Computers are an entire ecosystem with multiple levels of abstraction.

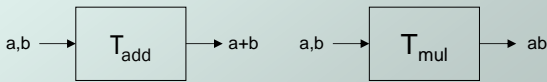
## Big Idea #1: Universal Computing Devices

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



## 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

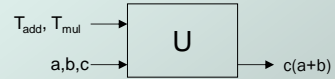
Turing machine that multiplies

For more info about Turing machines, see [http://www.wikipedia.org/wiki/Turing\\_machine/](http://www.wikipedia.org/wiki/Turing_machine/)

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

## Universal Turing Machine

- A machine that can implement all Turing machines -- this is also a Turing machine!
  - inputs: data, description of computation (other TMs)



Universal Turing Machine

Universal machine is **programmable** – so is a computer!

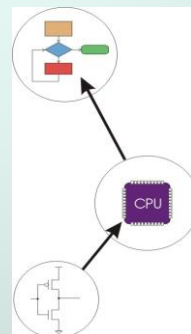
- instructions are part of the input data
- a computer can emulate a Universal Turing Machine

**A computer is a universal computing device.**

## From Theory to Practice

- In theory, computer can **compute** anything that can possibly be computed
  - 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/energy
    - cell phone, handheld video game, ...

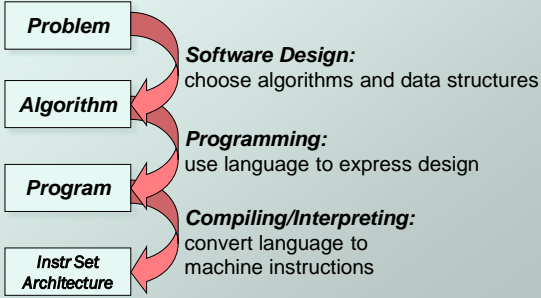
## Big Idea #2: Transformations Between Layers



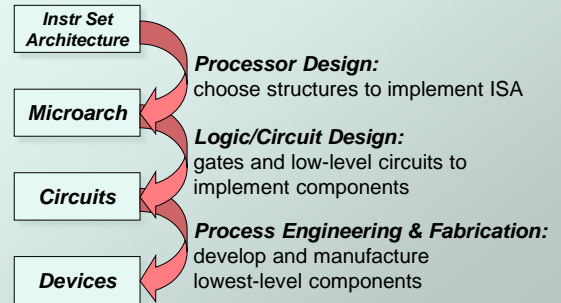
- Problems
- 
- Algorithms
- 
- Language
- 
- Instruction Set Architecture
- 
- Microarchitecture
- 
- Circuits
- 
- Devices

## How do we solve a problem using a computer?

- A systematic sequence of transformations between layers of abstraction.



## Deeper and Deeper...



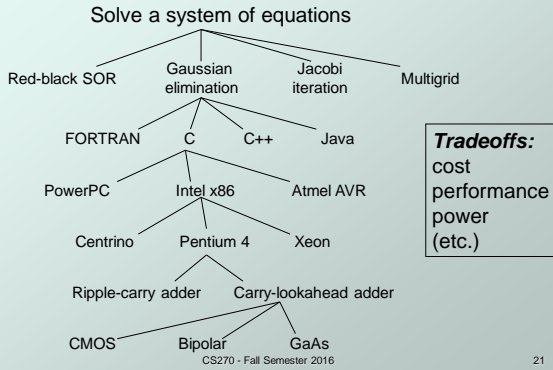
## Descriptions of Each Level

- **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 computer can perform
  - data types, addressing mode

## 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

## Many Choices at Each Level



## Book Outline

- **Bits and Bytes**
    - How do we represent information using electrical signals?
  - **Digital Logic**
    - How do we build circuits to process information?
  - **Processor and Instruction Set**
    - How do we build a processor out of logic elements?
    - What operations (instructions) will we implement?
  - **Assembly Language Programming**
    - 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?
  - **C Programming**
    - How do we write programs in C?
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