



## Announcements

- Chapter 9 for today
- Guest speaker on Monday
  - Ian King from the Living Computer Museum

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1



## Announcements

- Project 1A due tonight at 10pm
  - 1-1-1 rule: Monday at 10pm

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## Announcements

- Clicker scoring
  - 2 points for correct answers
  - 1 point for incorrect answers

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## Announcements

- How does that work when there are 5 points possible per day?
  - Random number of questions each day
    1. Total your score
      - 12 correct out of 15
    2. Find the percentage correct
      - .80
    3. Multiply the percentage by 5
      - $.80 \times 5 = 4$
    4. Record your score
      - 4 points

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## Copyright

- Copyleft
- Creative Commons
- Fair Use Doctrine
- Public domain
  - Copyright has expired (28 yrs x 2 + 50)
  - Created by a government agency
- Copyright not listed anywhere
  - Copyright because someone made it
  - Be sure to check the fine print at bottom of Web page

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## Announcements

- Guest speaker on Monday and Friday
  - Ian King, Curator of the Living Computer Museum
    - Paul Allen's computer museum
    - History of computers and the various breakthroughs
    - Next week's schedule on the calendar has been re-arranged

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## Vocabulary for Monday

- No reading is required
- Vocabulary and definitions for Monday
  - See the GoPost under Vocabulary
  - I'll add more terms this afternoon
  - Study the terms for Monday and the terms for Chapter 11

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## Announcements

- Wednesday
  - Project 1B
  - Algorithms
  - High- and low-level programming languages

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## Computer Basics

*How exactly does a computer work?*

© Lawrence Snyder, 2004

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## Integrated Circuits

Integrated circuits (ICs) are the power source of the information revolution

- When computers were made of discrete parts, wires of every transistor (3), capacitor (2), resistor (2), etc. had to be hand-connected
- Labor intensive, expensive, error prone, unreliable cumbersome, ... even with robots!
- Integrated circuits solved that by 2 ideas
  - Integration—circuits built as a unit from like parts
  - Photolithography—printing process to make chips

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10

## Videos—How they're made

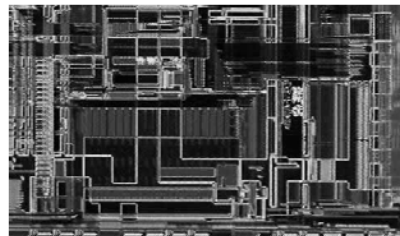
- Integrated Circuits (5:21)
- Microprocessor (6:48)
- Printed Circuit Boards (5:26)

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11

## Intel Pentium Processor



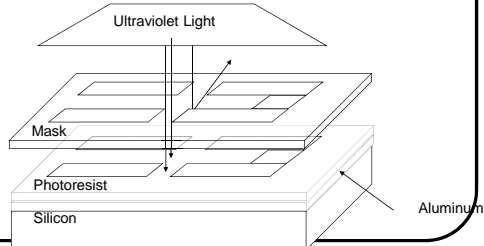
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## Photolithography

Consider process for depositing wires

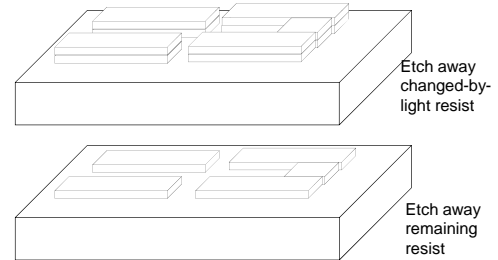


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## Remove Resist



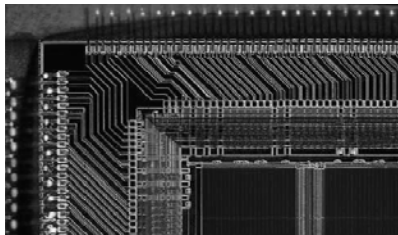
The cost of the circuit is not related to complexity

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## R4400 NEC/MIPS Processor



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## Semiconductors

Silicon, a semiconductor -- sometimes it conducts and sometimes it doesn't

- It's possible to control when semiconductors do and don't conduct

Compute by controlling conducting

Ex.: Use control to test **Mars AND rover**

Make semiconductor conduct if "Mars" is found

Make semiconductor conduct if "rover" is found

Send "yes" signal on wire

Detect presence/absence of "yes"

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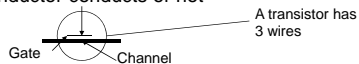
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16

## Field Effect

Charged objects are familiar -- use a nylon comb on a dry day

- A charged field can control whether a semiconductor conducts or not



The charge of the control wire (gate) is key

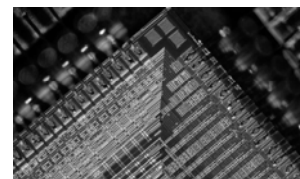
- Neutral gate, channel doesn't conduct
- Charged gate, channel conducts

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17

## MIPS R10000 Processor



Notice that wires cross over other wires ...

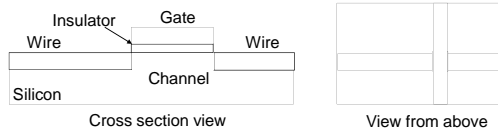
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## MOS Transistors

The field effect idea is implemented in metal-oxide-semiconductor transistors



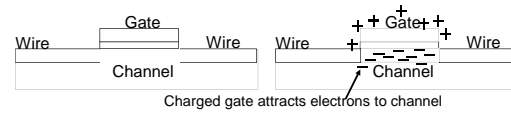
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## Operation

The two cases: the gate is neutral or the gate is charged



Notice key points of integrated circuits:  
Constructed as a unit of compatible parts  
Fabricated in layers by photolithography

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## Computers ...

Deterministically execute instructions to process information

"Deterministically" means that when a computer chooses the next instruction to perform it is required by its construction to execute a specific instruction based only on the program and input it is given

Computers have no free will and they are not cruel

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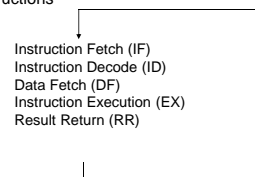
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## Fetch/Execute Cycle

Computer = instruction execution engine

- The fetch/execute cycle is the process that executes instructions

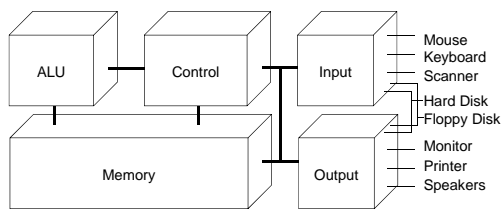


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## Anatomy of a Computer



The Hard Disk is the  $\alpha$ -device

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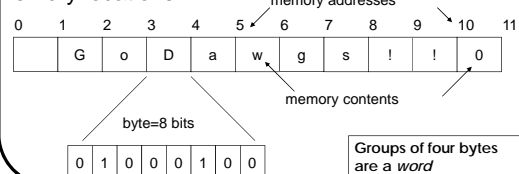
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## Memory ...

Programs and their data must be in the memory while they are running

Memory locations



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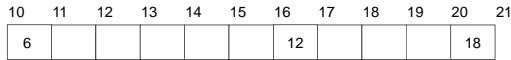
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## Control

The Fetch/Execute cycle is hardwired into the computer's control, i.e., it is the actual "engine"

The instructions executed have the form  
ADDB 10, 16, 20



Put in memory location 20 the contents of memory location 10 + contents of memory location 16

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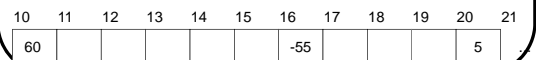
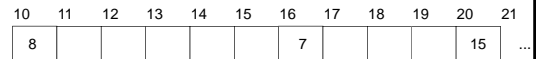
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## Indirect Data Reference

Instructions tell *where* the data is, not *what* the data is ... contents change

One instruction has many effects  
ADDB 10, 16, 20



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## ALU

The Arithmetic/Logic Unit does the actual computation

Each type of data has its own separate instructions  
 ADDB : add bytes      ADDBU : add bytes unsigned  
 ADDH : add half words    ADDHU : add halves unsigned  
 ADD : add words      ADDU : add words unsigned  
 ADDS : add short decimal numbers  
 ADDD : add long decimal numbers

Most computers have only about 100-150 hard-wired instructions

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## Input/Output

Input units bring data to memory from outside world; output units send data to outside world from memory

- Most peripheral devices are "dumb" meaning that the processor assists in their operation
- Disks are *memory* devices because they can output information and input it back again

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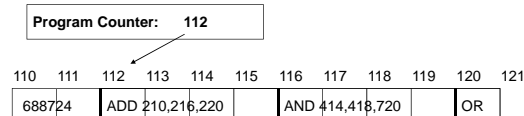
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## The PC's PC

The program counter (PC) tells where the next instruction comes from

- Instructions are a *word* long
  - Recall that 4 bytes is a word
- Add 4 to the PC to find the next instruction



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29

## Clocks Run The Engine

The rate a computer "spins around" the Fetch/Execute cycle is controlled by its clock

- Current clocks run 2-3 GHz
- In principle, the computer should do one instruction per cycle, but often it fails to
- Modern processors try to do more than one instruction per cycle, and often succeed

Clock rate is not a good indicator of speed

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## Animation

- Fetch-Execute Cycle

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## Summary

Semiconductors made Info Revolution

- Semiconductor properties ...
  - Fields control when semiconductor conducts
  - On/off of conductors allows us to compute

Fetch/execute cycle runs instructions

- 5 steps to interpret machine instructions
- Programs must be in the memory
- Data is moved in and out of memory

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Instructions, data are represented in binary

32



## Quiz topics

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## Monday

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34