

# Welcome to CSE370

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Instructor: Bruce Hemingway

TA: **Francis Iannacci**

Class web

<http://www.cs.washington.edu/370>

Add yourself to the mailing list→ see the web page

Today's lecture

Course overview: The Digital Age

Class rule: *Interrupt* when you don't understand *why* we are doing something

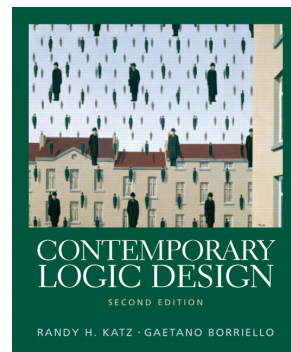
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# Text

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**Contemporary Logic Design (2nd Edition)**

- ◆ **Randy H. Katz, U. California, Berkeley and Gaetano Borriello, U. Washington, Seattle**



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## CSE 370-Workload

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- ◆ The course consists of the following elements:
- ◆ **Lectures:** There will be 26 lectures. Attendance and participation at all of them is strongly encouraged and expected.
- ◆ **Laboratory Assignments:** There will be a total of nine (9) laboratory assignments. Although you'll be able to use the lab all week, attendance at one of the scheduled times is very important as that is when the TAs will be available. We will work hard to ensure that the laboratory assignments take no more than the three hour sessions to complete. Laboratory assignments will be closely tied to the written homework assignments and are intended to give you a taste of working with real digital hardware. We will use them to reinforce key concepts. You should attend the session for which you are registered. With permission of the TA, you can attend the other section in case of unusual circumstances.
- ◆ **Reading:** We will cover most of the Contemporary Logic Design (2nd edition) text. Readings will be part of each weekly assignment.
- ◆ **Assignments:** Weekly problem sets involving digital logic analysis and design, to be solved with and without the use of computer-aided design tools. The last assignment will include a larger design project and will span two weeks.
- ◆ **In-class exams:** Two short **scheduled** in-class exams, throughout the quarter. Together these replace a mid-term exam. **NO MAKE-UPS!**
- ◆ **Final exam:** A two-hour exam during finals week.

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## Grading

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- ◆ We will compute your course grade as follows:
- ◆ 25%: weekly assignments
- ◆ 25%: laboratory assignments
- ◆ 25%: in-class exams
- ◆ 25%: final exam
- ◆ Your grade will be determined by how well you understand the material as evidenced by the assignments, labs and tests. We would like nothing better than to give the entire class a 4.0

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## Homework and Quizzes

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- ◆ **Assignments**

- ◆ Your weekly assignments are due at the beginning of class on the assigned due date. Assignments handed in during or immediately after class will incur a 10% penalty. We will penalize your assignment 10% per day for each additional day late. Assignments due Friday will be charged 20% if turned in over the weekend, 30% if turned in on Monday, etc.
- ◆ Assignment problems will sometimes be graded on a random basis. To get full credit for an assignment, you must, of course, turn-in solutions for each assigned problem. Only a subset of the problems will actually be graded in detail. You will not know in advance which problems this will be - so make sure to do all of them.
- ◆ Please review the assignment solutions carefully before questioning a grade with either the instructor or the teaching assistants.

- ◆ **Quizzes**

- ◆ There will be no makeup for missed quizzes. If you miss a quiz, you will receive a score of zero so please plan your schedule carefully. We do not have the resources to be able to give make-up quizzes. Please review the quiz solutions carefully before questioning a grade with either the instructor or the teaching assistants.

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## Collaboration and Cheating

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- ◆ **Collaboration**

- ◆ **Homework:** Unless specifically stated otherwise, we encourage collaboration on homework, provided (1) You spend at least 15 minutes on each and every problem alone, before discussing it with others, and (2) You write up each and every problem in your own writing, using your own words, and understand the solution fully. Copying someone else's homework is cheating (see below), as is copying the homework from another source (prior year's notes, etc.). The quiz problems will be very similar to the homework problems; if you truly understand the homework, then the quizzes will be easy. If you have copied the homework... **Quizzes:** A quiz is a short exam—no collaboration or discussion is permitted. If you have a question during a quiz, ask the instructor.

- ◆ **Cheating**

- ◆ Cheating is a very serious offense. If you are caught cheating, you can expect initiation of a cheating case in the University system. Basically, cheating is an insult to the instructor, to the department and major program, and most importantly, to you. If you feel that you are having a problem with the material, or don't have time to finish an assignment, or have any number of other reasons to cheat, then talk with the instructor. Just don't cheat. To avoid creating situations where copying can arise, never e-mail or post your solution files. You can post general questions about interpretation and tool use but limit your comments to these categories. If in doubt about what might constitute cheating, send the instructor email describing the situation.

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## Why you are here

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- ◆ Required class
- ◆ To learn about digital design
  - Design process and techniques
  - The basis for digital computing
- ◆ Exposure to new ideas
  - Emergent behavior
    - ✦ Complex functions from simple elements
    - ✦ With only NORs and wire you can build a computer
  - Parallel computation
    - ✦ Digital hardware is inherently parallel

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## The Digital Age

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- ◆ Computing is in its infancy
  - Processing power
    - ✦ Doubles every 18 months
    - ✦ Factor of 100 / decade
  - Disk capacity
    - ✦ Doubles every 12 months
    - ✦ Factor of 1000 / decade
  - Optical fiber transmission capacity
    - ✦ Doubles every 9 months
    - ✦ Factor of 10,000 / decade
- ◆ The bases are mathematics and switches
  - How did we get here?

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## Diophantus of Alexandria b. ~200 BCE

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DIOPHANTI  
ALEXANDRINI  
ARITHMETICORVM  
LIBRI SEX,  
ET DE NVMERIS MVLTIANGVLIS  
LIBER VNVS.

CVM COMMENTARIIS C. G. BACHETTI F. G.  
& OBSERVATIONIBUS D. P. DE FERMAT SENATORIS TULOSANI.  
Accessit Doctrina Analytica inuenum nouum, collectum  
ex varijs eiusdem D. de FERMAT Epistolis.



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- Known as the “father of algebra”
- *Arithmetica* is a collection of 130 problems that gives numerical solutions of determinate equations, which have a unique solution, and indeterminate equations.
- The Later Alexandrian Age was a time when mathematicians were discovering many ideas that lead to our concept of mathematics today.

## 850 AD

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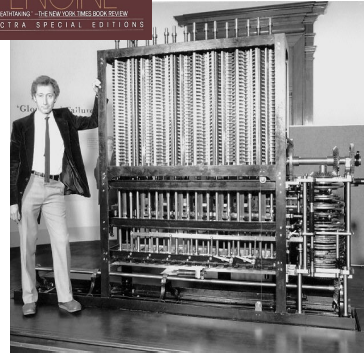
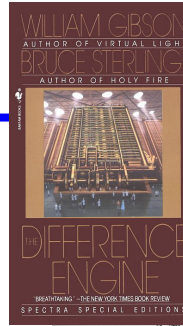


- ◆ Abu Ja'far Muhammad ibn Musa **al-Khwarizmi**
- ◆ Lived in Baghdad, 780 to 850 AD. One of the first to write on algebra (using words, not letters) and also Hindu-Arabic numbers (1, 2, 3, ...).
- ◆ From his name and writings came the words "algebra" and "algorithm".
- ◆ Book: Hisab **al-jabr** w'al muqabala

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## 1822

- ◆ Charles Babbage
  - Father of computing
- ◆ 1822 Difference Engine
  - A calculator
- ◆ 1834 Analytical Engine
  - A computer
  - Programmable

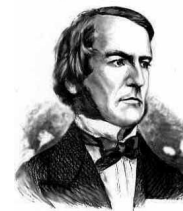


Analytical Engine

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## 1854

- ◆ George Boole
  - Boolean algebra
- ◆ Number system with 2 values
  - 0/1  $\Leftrightarrow$  false/true
  - Do math on logic statements
  - 3 operations (NOT, AND, OR)



All computers use Boolean algebra

### NOT

A	Out
0	1
1	0

### AND

A	B	Out
0	0	0
0	1	0
1	0	0
1	1	1

### OR

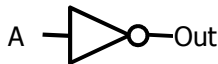
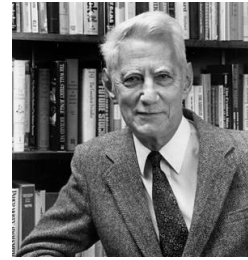
A	B	Out
0	0	0
0	1	1
1	0	1
1	1	1

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1938

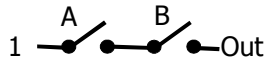
◆ Claude Shannon

- Implemented Boolean algebra using switches
- Described information using binary digits (**bits**)



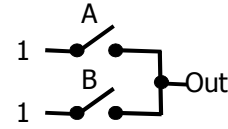
**NOT**

A	Out
0	1
1	0



**AND**

A	B	Out
0	0	0
0	1	0
1	0	0
1	1	1



**OR**

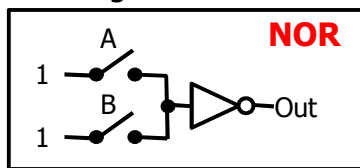
A	B	Out
0	0	0
0	1	1
1	0	1
1	1	1

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Computer Hardware

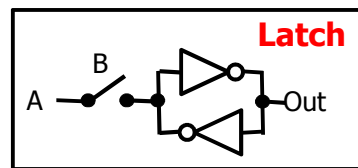
◆ Components

■ Logic

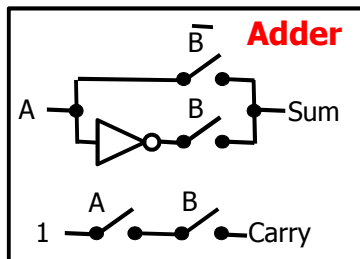


**NOR**

■ Memory



**Latch**



**Adder**

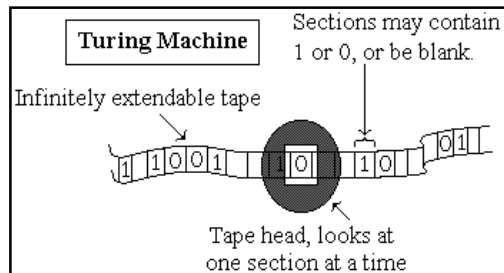
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

**Adder**

## 1937

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- ◆ Alan Turing
  - Turing Machines
- ◆ Simple computer model
  - Can something be computed?



Also pioneered artificial intelligence



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## 1945

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- ◆ John von Neumann
  - First stored computer program
- ◆ A sequence of operations
  - Read from memory
  - Operate using logic gates
  - Store result into memory



Other contributions:  
Quantum Mechanics  
Cellular Automata  
Game Theory

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## Stored Programs = Software

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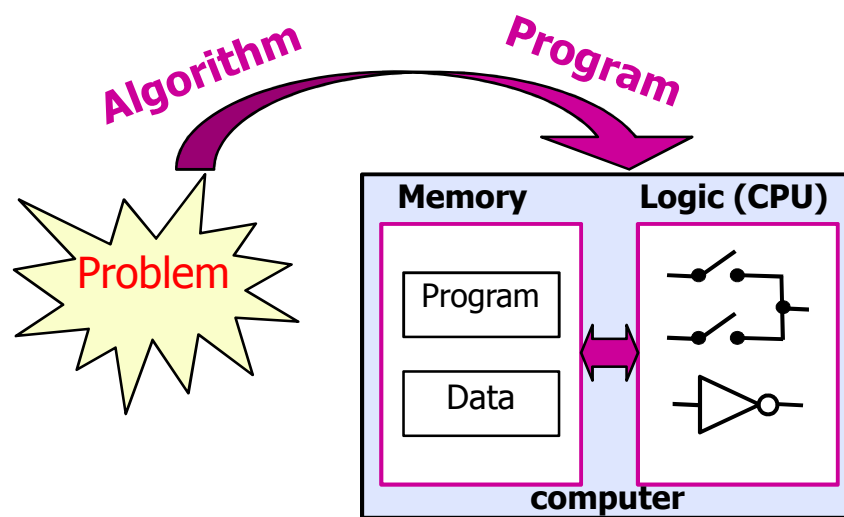


Bill Gates and Paul Allen, Lakeside, 1968

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## Hardware + Software

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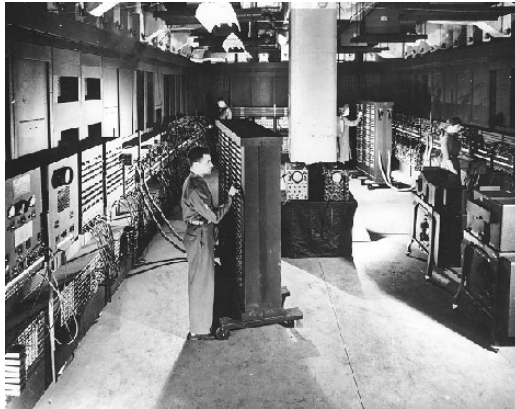


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1946

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- ◆ ENIAC...the first computer
  - Vacuum tubes for switches



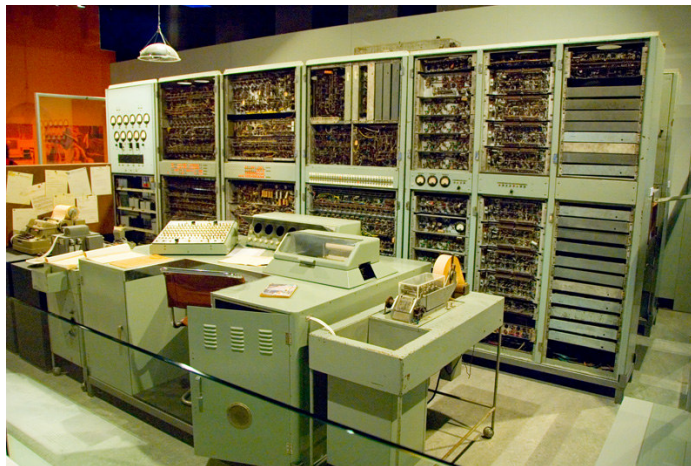
1000x faster than anything before...  
19,000 tubes  
200 kilowatts  
357 multiplies per second

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1947-1950 CSIRAC

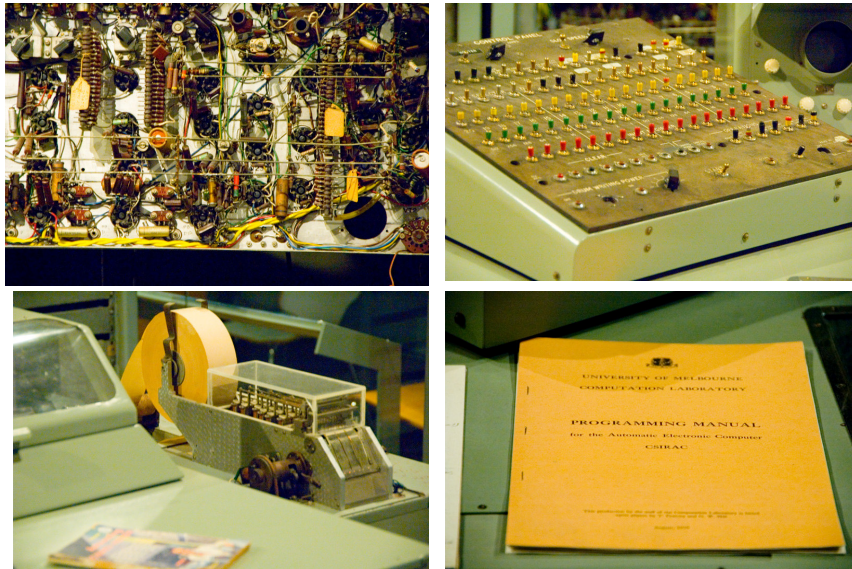
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- ◆ Australia's first computer- the only survivor

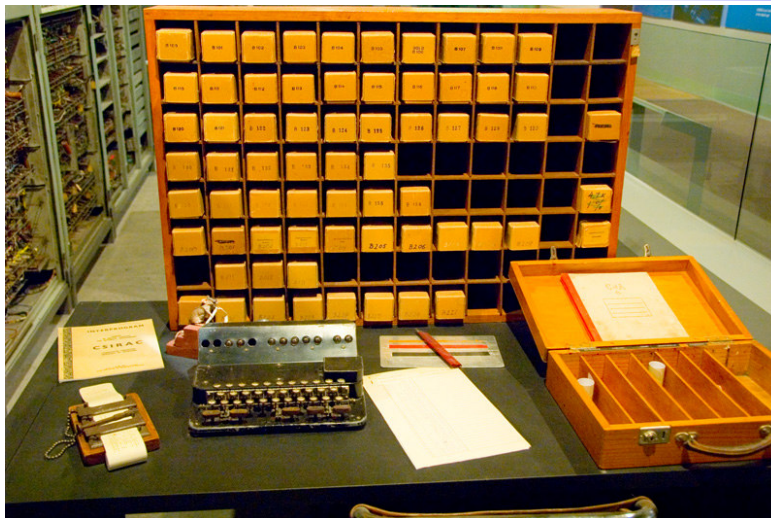


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## CSIRAC



## CSIRAC- subroutine library



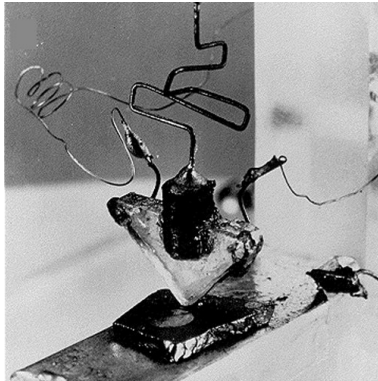
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1947



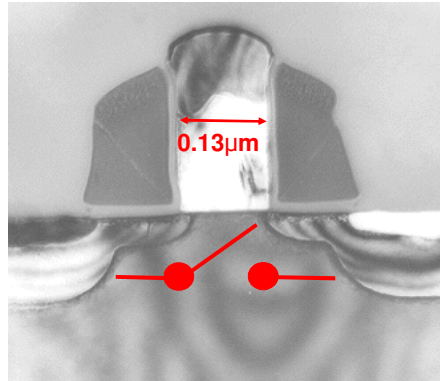
◆ Bardeen, Brattain, Shockley invent the transistor

1947



Nobel Prize, 1956

2000



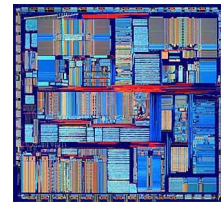
Courtesy Mark Bohr, Intel

1958



◆ Kilby and Noyce invent the integrated circuit

Pentium

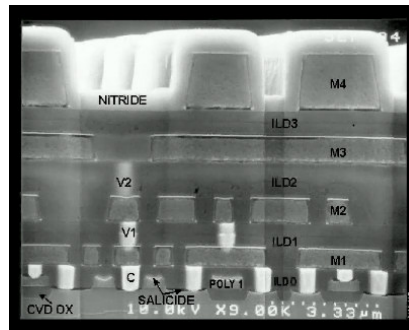


2000

1958



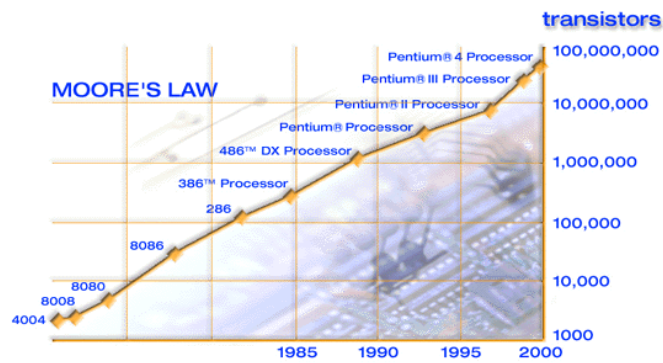
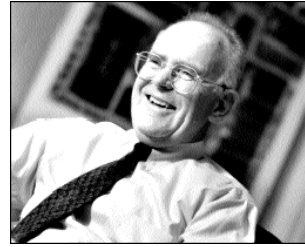
Nobel Prize, 2000



Courtesy Yan Borodovsky, Intel

## 1965

- ◆ Gordon Moore
  - Moore's Law: The transistor density of silicon chips doubles every 18 months

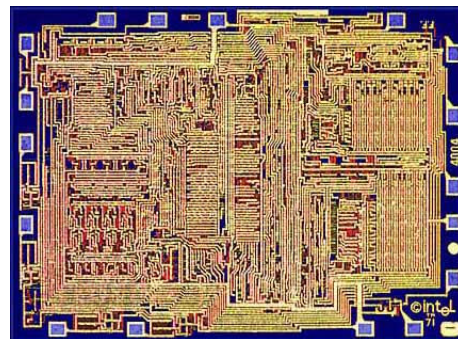


## 1971

- ◆ Ted Hoff invents the microprocessor

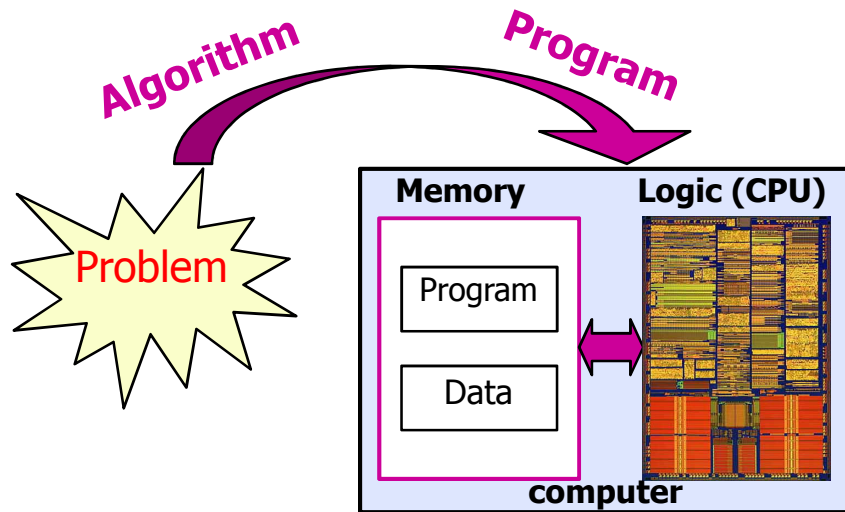


- ◆ Intel 4004
  - 2,300 transistors
  - 3 mm by 4 mm
  - As powerful as the ENIAC



## Hardware + Software + Technology

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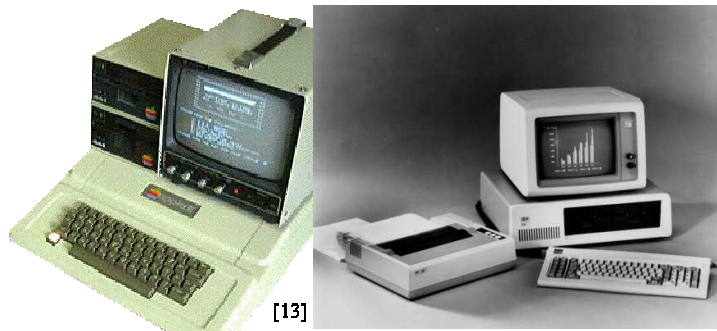


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## 1977 and 1981

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- ◆ Apple II and IBM PC
  - The first microcomputers

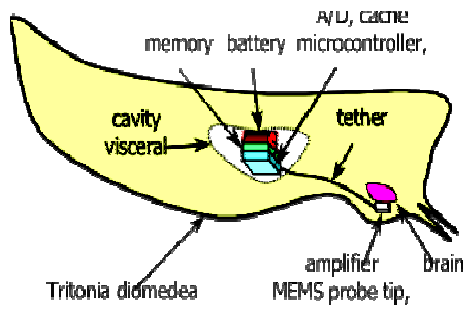


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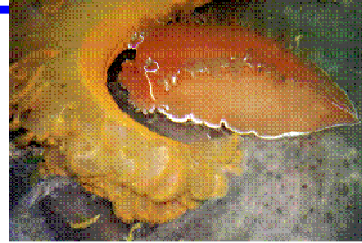
## A modern example

- ◆ Goal: Interface a computer to an animal brain
  - Measure brain signals in intact animals

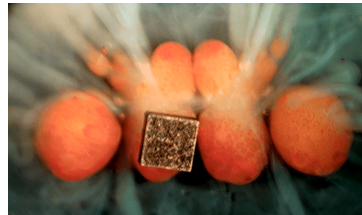


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Tritonia and seapen



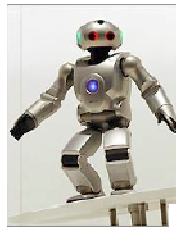
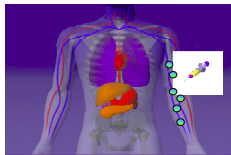
Brain with implanted chip



Courtesy Jim Beck and Russell Wyeth

## More modern examples

- ◆ Computing everywhere
  - Wireless/wired networking
  - Wearable devices
  - Smart sensors



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## What is logic design?

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- ◆ Using digital logic...
  - The underlying basis is Boolean algebra
  - The physical basis is transistor switches
- ◆ ...to solve a problem...
  - Within size, cost, and other bounds
  - Within the constraints imposed by our bases
    - ✦ Encode as logical statements
    - ✦ Compile into physical hardware
- ◆ ...with logical values encoded as physical quantities
  - If ( $0V < \text{voltage} < 0.8V$ ) then symbol is a "0"
  - If ( $2.0V < \text{voltage} < 5V$ ) then symbol is a "1"

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## Terminology

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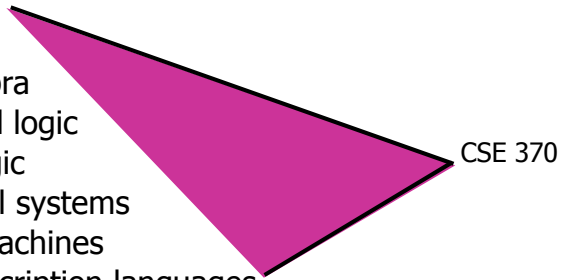
- ◆ Digital: Discrete-valued
  - Usually binary
  - Transistor switches have 2 states (on/off)
- ◆ Combinational: Without memory
  - Output depends on present input
- ◆ Sequential: With memory (state)
  - Output depends on present and/or past inputs
- ◆ Synchronous: Values change at discrete timesteps
  - Synchronous ☒ clocked

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## What you will learn in CSE370

- ◆ Physical devices (transistors, resistors, wires)
- ◆ Switches
- ◆ Truth tables
- ◆ Boolean algebra
- ◆ Combinational logic
- ◆ Sequential logic
- ◆ State in digital systems
- ◆ Finite-state machines
- ◆ Hardware description languages
- ◆ Register-transfer description
- ◆ Concurrent abstract specifications



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