

CSC 121

Computers and Scientific Thinking

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The History of Science & Computing

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Science and Computing



DYK?

- what is science?
- when did it originate? by whom?
- were the Middle Ages really the Dark Ages?
- what was the so-called Scientific Revolution?
- what is the scientific method?
- when were computers invented? by whom?
- when were computers accessible/affordable to individuals?
- when was the Internet invented? the Web?
- how did Bill Gates get so rich?

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Early science



science: a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method (Merriam-Webster dictionary)

science is important in our daily lives because:

- it advances our understanding of the world and our place in it
- scientific advances can lead to practical applications (e.g., technology, medicine, ...)

modern science traces its roots back to the Greek natural philosophers

- Thales (6th century B.C.) is considered by some to be the "first scientist"
 - he made observation/predictions about nature (weather, geography, astronomy, ...)
- Plato (4th century B.C.) proposed a grand theory of cosmology
 - claimed heavenly bodies move uniformly in circles, because of geometric perfection
 - believed observation was confused and impure, truth was found through contemplation
- Aristotle (4th century B.C.) proposed a coherent and common-sense vision of the natural world that stood for 2,000 years
 - studied and wrote on a cosmology, physics, biology, anatomy, logic, ...
 - placed greater emphasis on observation than Plato, but still not experimental
 - tutored Alexander the Great

Greek natural philosophy is sometimes called "pre-scientific", since it relied on contemplation or observation, but not experimentation

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Roman times → Middle Ages



Roman civilization built upon the tradition of Greek natural philosophy

- the Romans are better known for engineering than theoretical science
- Galen (2nd century) studied human anatomy and physiology
- Ptolemy (2nd century) tweaked the Plato/Aristotle cosmology to match observations of the planets

the fall of Rome (in 476) led to a discontinuity in western civilization

- in western Europe, population dropped, literacy virtually disappeared, and Greek knowledge was lost
- in eastern Europe, Greek knowledge was suppressed by orthodox Christianity in the Byzantine Empire (which finally fell in 1453)
- the only repositories of knowledge were monasteries and medieval universities (which started forming in the 12th century) "DARK AGES?"

medieval Islam became the principal heir to Greek science

- in the 7th-14th centuries, the Islamic Empire covered parts of Europe, northern Africa, the Middle East, and western Asia
- Greek writings were preserved and advanced by Arab scholars
- the term "algorithm" is named after Persian scholar Muhammad ibn Musa al-Khwarismi

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Scientific Revolution



the Renaissance (15th-16th centuries) was instigated by the rediscovery of Greek science

- Greek and Latin texts were retrieved from monasteries & Islamic libraries
- Leonardo da Vinci (1452-1519) was artist, astronomer, geometer, engineer, ...
- Guttenberg's printing press made the broad dissemination of knowledge possible

the Scientific Revolution (16th-17th centuries) was brought about by a period of intellectual upheaval in Europe

- the Protestant Reformation, new World exploration, Spanish inquisition, ...
- the cultural environment allowed for questioning religious and scientific dogma

- the universe was viewed as a complex machine that could be understood through careful observation and experimentation

- Copernicus proposed a sun-centered cosmology (1543)
 - Kepler refined the heliocentric model, using elliptical orbits (1609)
- Galileo pioneered the use of experimentation to validate observational theories
 - considered the father of modern physics & the father of modern astronomy
- Newton described universal gravitation, laws of motion, classical mechanics (1687)

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Modern Science



the Scientific Revolution established science as the preeminent source for the growth of knowledge

- science became professionalized and institutionalized

the scientific method provides the common process by which modern science is conducted



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History of computing

calculating devices have been around for millennia (e.g., abacus ~3,000 B.C.)

modern "computing technology" traces its roots to the 16-17th centuries

- as part of the "Scientific Revolution", people like Kepler, Galileo, and Newton viewed the natural world as mechanistic and understandable
- this led to technological advances & innovation

from simple mechanical calculating devices to powerful modern computers, computing technology has evolved through technological breakthroughs

	Time Period	Defining Technology
Generation 0	1642–1945	Mechanical devices (e.g., gears, relays)
Generation 1	1945–1954	Vacuum tubes
Generation 2	1954–1963	Transistors
Generation 3	1963–1973	Integrated circuits
Generation 4	1973–1985	Very large scale integration (VLSI)
Generation 5	1985–????	Parallel processing and networking

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Generation 0: Mechanical Computers

1642 – Pascal built a mechanical calculating machine

- used mechanical gears, a hand-crank, dials and knobs
- other similar machines followed



1805 – the first programmable device was Jacquard's loom

- the loom wove tapestries with elaborate, programmable patterns
- a pattern was represented by metal punch-cards, fed into the loom
- using the loom, it became possible to mass-produce tapestries, and even reprogram it to produce different patterns simply by changing the cards



mid 1800's – Babbage designed his "analytical engine"

- its design expanded upon mechanical calculators, but was programmable via punch-cards (similar to Jacquard's loom)
- Babbage's vision described the general layout of modern computers
- he never completed a functional machine – his design was beyond the technology of the day

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Generati on 0 (cont.)

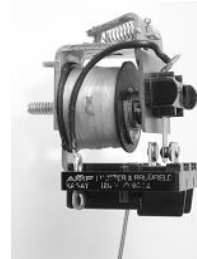
1890 – Hollerith invented tabulating machine

- designed for tabulating 1890 U.S. Census data
- similar to Jacquard's loom and Babbage's analytical engine, it stored data on punch-cards, and could sort and tabulate using electrical pins
- using Hollerith's machine, census data was tabulated in 6 weeks (vs. 7 years for the 1880 census)
- Hollerith's company would become IBM



1930's – several engineers independently built "computers" using electromagnetic relays

- an electromagnetic relay is physical switch, which can be opened/closed via electrical current
- Zuse (Nazi Germany) – his machines were destroyed in WWII
- Atanasoff (Iowa State) – built a partially-working machine with his grad student
- Stibitz (Bell Labs) – built the MARK I computer that followed the designs of Babbage
 - limited capabilities by modern standards: could store only 72 numbers, required 1/10 sec to add, 6 sec to multiply
 - still, 100 times faster than previous technology



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Generati on 1: Vacuum Tubes

mid 1940's – vacuum tubes replaced relays

- a vacuum tube is a light bulb containing a partial vacuum to speed electron flow
- vacuum tubes could control the flow of electricity faster than relays since they had no moving parts
- invented by Lee de Forest in 1906



1940's – hybrid computers using vacuum tubes and relays were built

COLOSSUS (1943)

- first "electronic computer", built by the British govt. (based on designs by Alan Turing)
- used to decode Nazi communications during the war
- the computer was top-secret, so did not influence other researchers

ENIAC (1946)

- first publicly-acknowledged "electronic computer", built by Eckert & Mauchly (UPenn)
- contained 18,000 vacuum tubes and 1,500 relays
- weighed 30 tons, consumed 140 kwatts



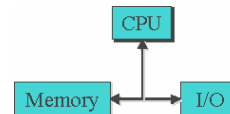
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Generati on 1 (cont.)

- COLOSSUS and ENIAC were not general purpose computers
- could enter input using dials & knobs, paper tape
 - but to perform a different computation, needed to reconfigure

- von Neumann popularized the idea of a "stored program" computer
- Memory stores both data and programs
 - Central Processing Unit (CPU) executes by loading program instructions from memory and executing them in sequence
 - Input/Output devices allow for interaction with the user

virtually all modern machines follow this
von Neumann Architecture
(note: same basic design as Babbage)



- programming was still difficult and tedious
- each machine had its own machine language, 0's & 1's corresponding to the settings of physical components
 - in 1950's, assembly languages replaced 0's & 1's with mnemonic names
e.g., ADD instead of 00101110

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Generati on 2: Transistors

- mid 1950's – transistors began to replace tubes
- a transistor is a piece of silicon whose conductivity can be turned on and off using an electric current
 - they performed the same switching function of vacuum tubes, but were smaller, faster, more reliable, and cheaper to mass produce
 - invented by Bardeen, Brattain, & Shockley in 1948 (earning them the 1956 Nobel Prize in physics)

some historians claim the transistor was the most important invention of the 20th century



- computers became commercial as cost dropped
high-level languages were designed to make programming more natural

- FORTRAN (1957, Backus at IBM)
- LISP (1959, McCarthy at MIT)
- BASIC (1959, Kemeny at Dartmouth)
- COBOL (1960, Murray-Hopper at DOD)

the computer industry grew as businesses could afford to buy and use computers
Eckert-Mauchly (1951), DEC (1957)
IBM became market force in 1960's

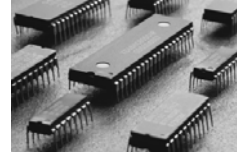


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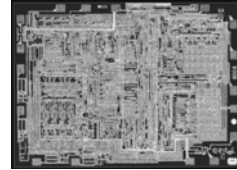
Generati on 3: Integrated Ci rcui ts

mid 1960's - integrated circuits (IC) were produced

- Noyce and Kilby independently developed techniques for packaging transistors and circuitry on a silicon chip (Kilby won the 2000 Nobel Prize in physics)
- this advance was made possible by miniaturization & improved manufacturing
- allowed for mass-producing useful circuitry



1971 – Intel marketed the first *microprocessor*, the 4004, a chip with all the circuitry for a calculator



1960's saw the rise of Operating Systems

- recall: an operating system is a collection of programs that manage peripheral devices and other resources
- in the 60's, operating systems enabled time-sharing, where users share a computer by swapping jobs in and out
- as computers became affordable to small businesses, specialized programming languages were developed
Pascal (1971, Wirth), C (1972, Ritchie)

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Generati on 4: VLSI

late 1970's - Very Large Scale Integration (VLSI)

- by the late 1970's, manufacturing advances allowed placing hundreds of thousands of transistors w/ circuitry on a chip
- this "very large scale integration" resulted in mass-produced microprocessors and other useful IC's
- since computers could be constructed by simply connecting powerful IC's and peripheral devices, they were easier to make and more affordable

Year	Intel Processor	Number of Transistors ⁴
2006	Core 2 Duo	291,000,000
2000	Pentium 4	42,000,000
1999	Pentium III	9,500,000
1997	Pentium II	7,500,000
1993	Pentium	3,100,000
1989	80486	1,200,000
1985	80386	275,000
1982	80286	134,000
1978	8088	29,000
1974	8080	6,000
1972	8008	3,500
1971	4004	2,300

(Intel Research. "Silicon—Moore's Law." October 2006.)

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Generati on 4: VLSI (cont.)

with VLSI came the rise of personal computing

- 1975 - Bill Gates & Paul Allen founded Microsoft
Gates wrote a BASIC interpreter for the first PC (Altair)
- 1977 - Steve Wozniak & Steve Jobs founded Apple
went from Jobs' garage to \$120 million in sales by 1980
- 1980 - IBM introduced PC
Microsoft licensed the DOS operating system to IBM
- 1984 - Apple countered with Macintosh
introduced the modern GUI-based OS (which was mostly developed at Xerox)
- 1985 - Microsoft countered with Windows

Richest People in the World (Forbes.com, 3/8/07)	
1. Bill Gates	\$56 billion
2. Warren Buffet	\$52 billion
3. Carlos Slim Helu	\$49 billion
4. Ingvar Kamprad	\$33 billion
5. Lakshmi Mittal	\$32 billion
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19. Paul Allen	\$18 billion

1980's - object-oriented programming began

- represented a new approach to program design which views a program as a collection of interacting software objects that model real-world entities
- Smalltalk (Kay, 1980), C++ (Stroustrup, 1985), Java (Sun, 1995)

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Generati on 5: Paral l e l i sm/Networks

the latest generation of computers is still hotly debated

- no new switching technologies, but changes in usage have occurred

high-end machines (e.g. Web servers) can have multiple CPU's

- in 1997, highly parallel Deep Blue beat Kasparov in a chess match
- in 2003, successor Deep Junior played Kasparov to a draw

Year	Computers on the Internet ^a	Web Servers on the Internet ^b
2006	439,286,364	88,166,395
2004	285,139,107	52,131,889
2002	162,128,493	33,082,657
2000	93,047,785	18,169,498
1998	36,739,000	4,279,000
1996	12,881,000	300,000
1994	3,212,000	3,000
1992	992,000	50

^(a)Internet Domain Survey. * Internet Software Consortium, July 2006.

^(b)Netcraft Web Server Survey. * Netcraft, July 2006.)

most computers today are networked

- the Internet traces its roots to the 1969 ARPANet
mainly used by government & universities until the late 80s/early 90s
- the Web was invented by Tim Berners-Lee in 1989
designed to allow physics researchers to share data and documents
not popular until 1993 when Marc Andreessen developed a graphical browser (Mosaic)
Andreessen would go on to found Netscape, and Internet Explorer soon followed

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