

COS 109

Lecture 2: What is a computer?

What's in a computer?

- **logical or functional organization: "architecture"**
 - what the pieces are, what they do, how they work
 - how they are connected, how they work together
 - what their properties are
- **physical structure**
 - what they look like, how they are made
- **major pieces**
 - processor ("central processing unit" or CPU)
does the work, controls the rest
 - primary memory (RAM = random access memory)
stores instructions and data while computer is running
 - secondary memory (disk, drive, SSD)
stores everything even when computer is turned off
 - other devices ("peripherals")

Freshman SCI computer for class of 2023

Apple - MacBook Air 13.3" Laptop with Touch ID - Intel Core i5 - 8GB Memory
- 256GB Solid State Drive (Latest Model) - Space Gray

Model: MVFJ2LL/A SKU: 6356923

Price Match Guarantee
\$1,099.99 c

Save \$200

Solid State Drive Capacity



256 gigabytes

System Memory (RAM) ⓘ



8 gigabytes

Graphics

Intel Iris Plus Graphics 640

Processor Speed (Base) ⓘ



2.3 gigahertz

Processor Model ⓘ



Intel 7th Generation Core i5

Processor Model Number

Not Available

Operating System ⓘ



Mac OS

Battery Life ⓘ

10 hours

Battery Type

Lithium-polymer



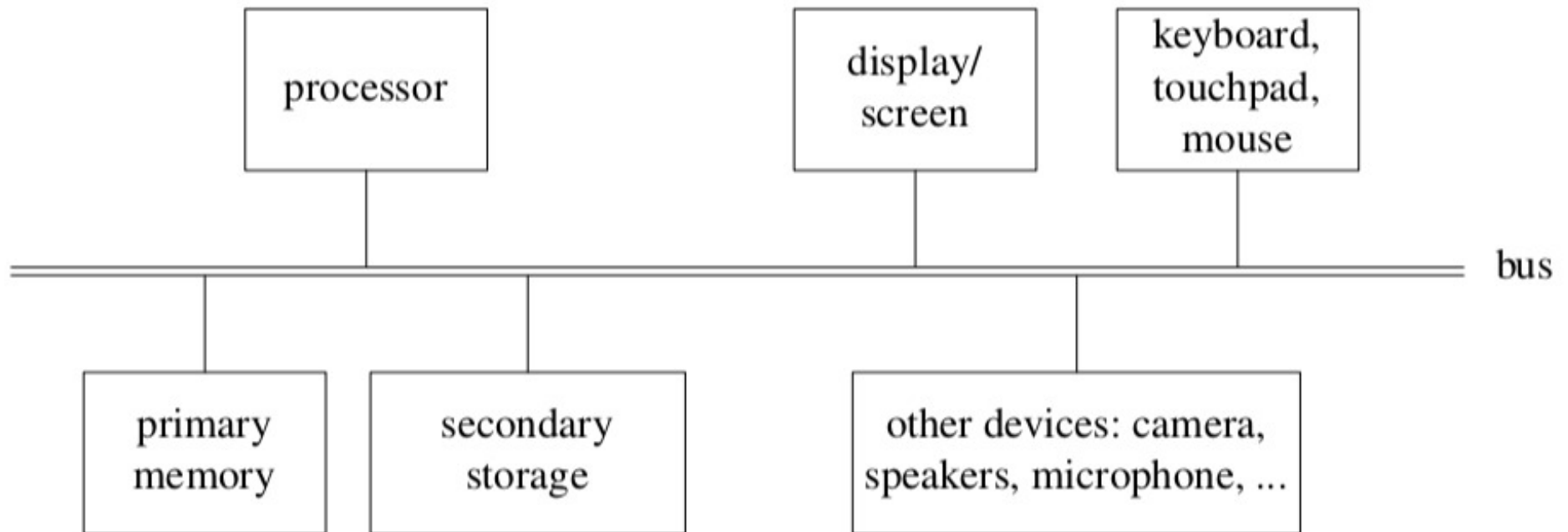
2009 freshman offering:

Apple iBook

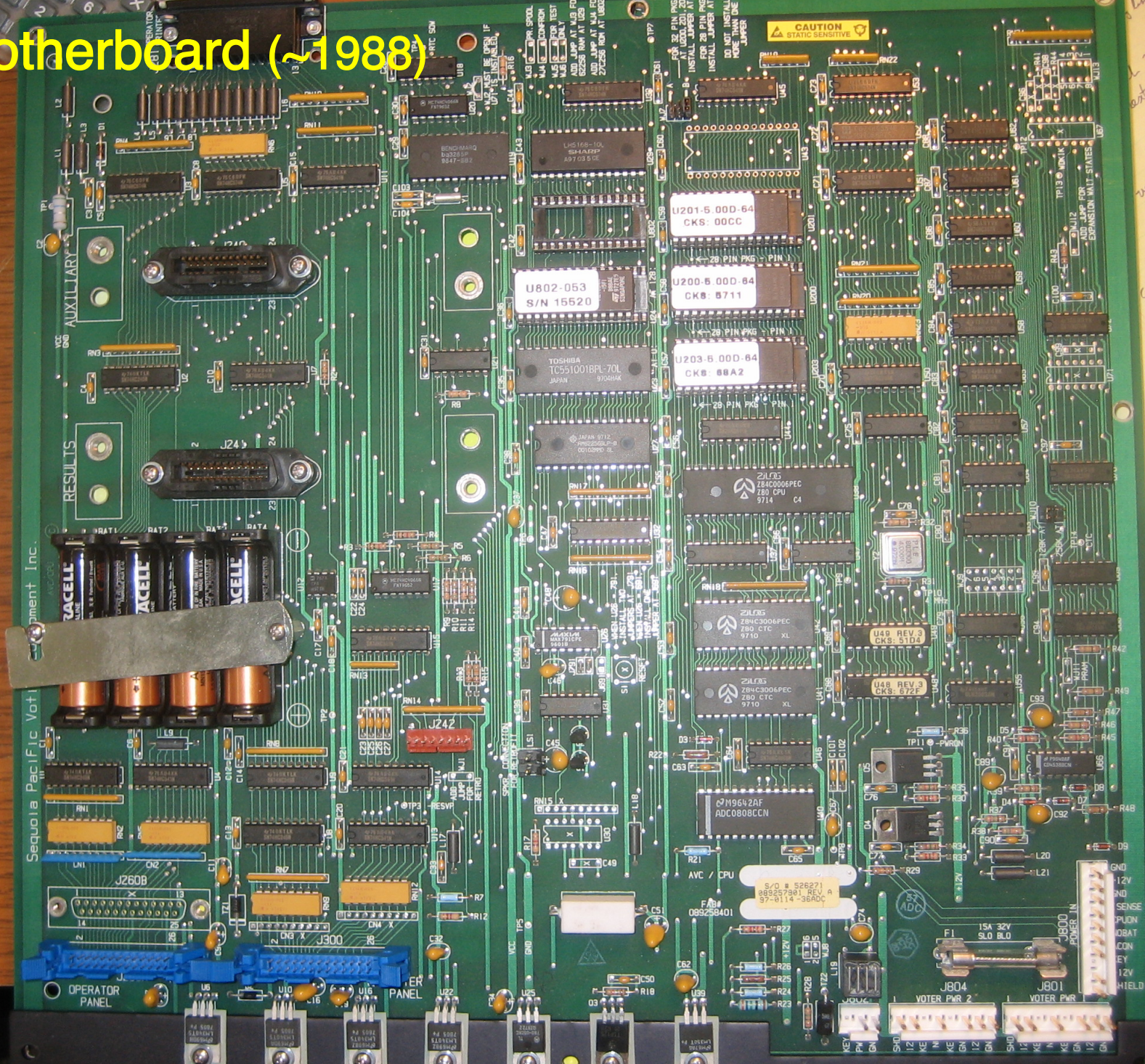
- 1.33Ghz G4 PowerPC processor
- 12.1" viewable display
- ATI Mobility Radeon 9550 with 32MB
- 512MB RAM, 1 DIMMs
- 60GB hard drive, 4200RPM
- 4.9 lbs.
- AirPort Extreme Card included
(802.11 b/g)
- Bluetooth included
- DVD/CD-RW Combo drive
- up to 6 hours of battery life
- Built-in Ethernet and Modem
- Built-in sound and speakers



Block diagram of a typical laptop computer

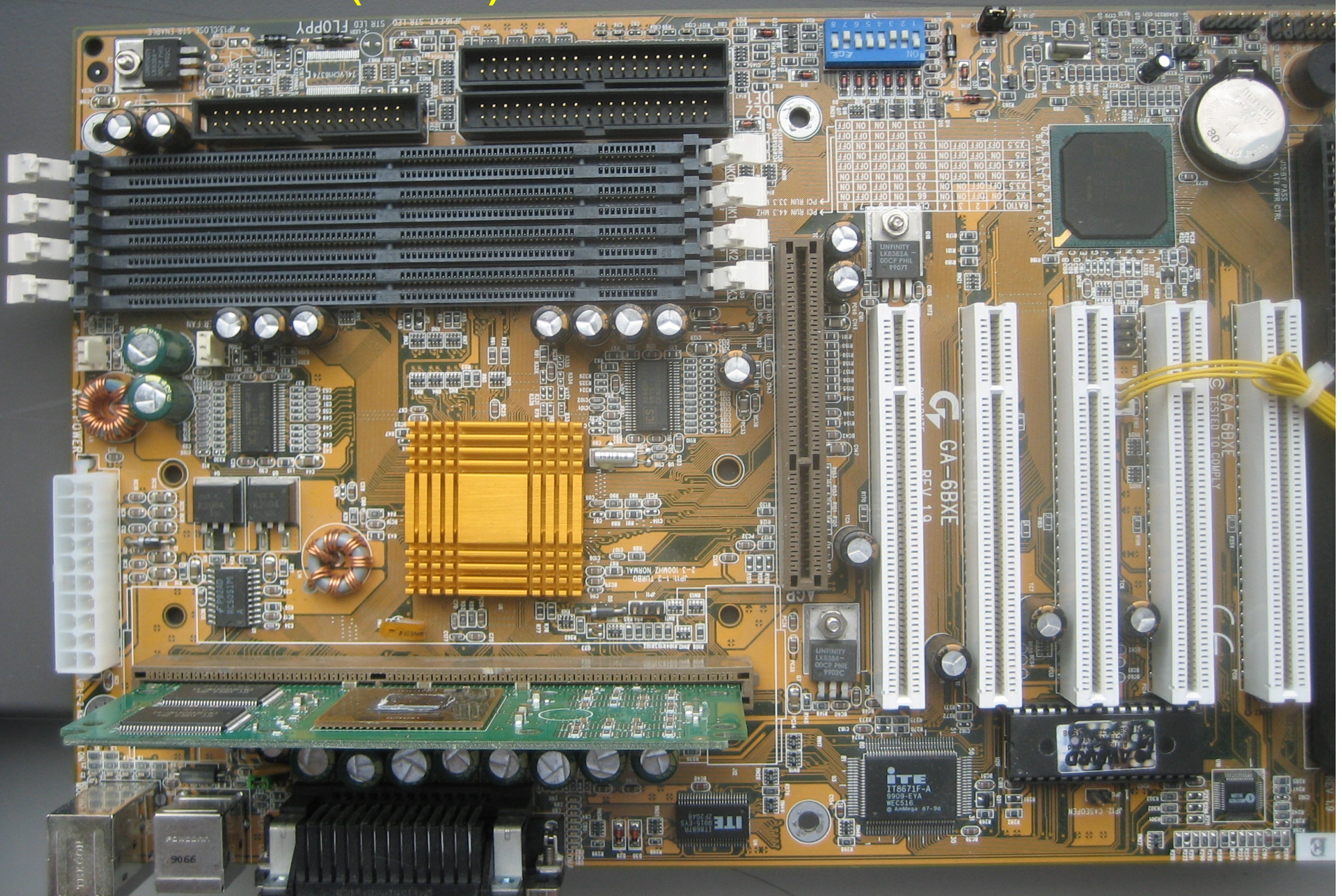


Motherboard (~1988)

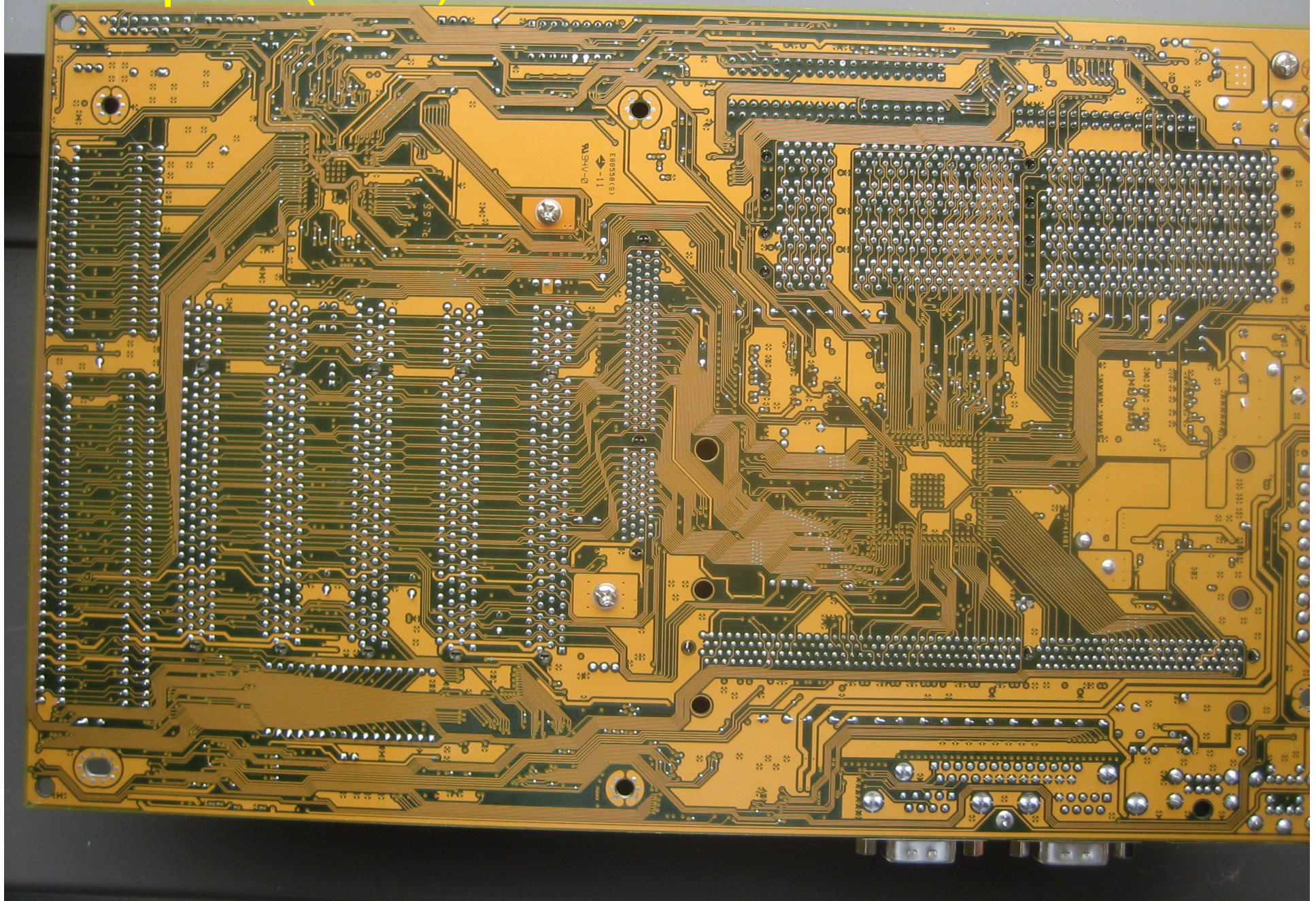


a new
 like C++ or Java
 2. state driven
 not larger than toy machine
 version of Toy machine
 compiler, assembly

Motherboard (~1998)



Backplane (~1998)



Processor or CPU (Central Processing Unit)

- can perform a small set of basic operations ("instructions")
 - arithmetic: add, subtract, multiply, divide, ...
 - memory access:
 - fetch information from memory, store results back into memory
 - decision making: compare numbers, letters, ...
 - decide what to do next depending on result of previous computations
 - control the rest of the machine
 - tell memory to send data to display; tell disk to read data from network; ...
- operates by performing sequences of simple operations very fast
- instructions to be performed are stored in the same memory as the data is
 - instructions are encoded as numbers: e.g., Add = 1, Subtract = 2, ...
- the processor is a general-purpose device: putting different instructions into the memory makes it do a different task
 - this is what happens when you run different programs



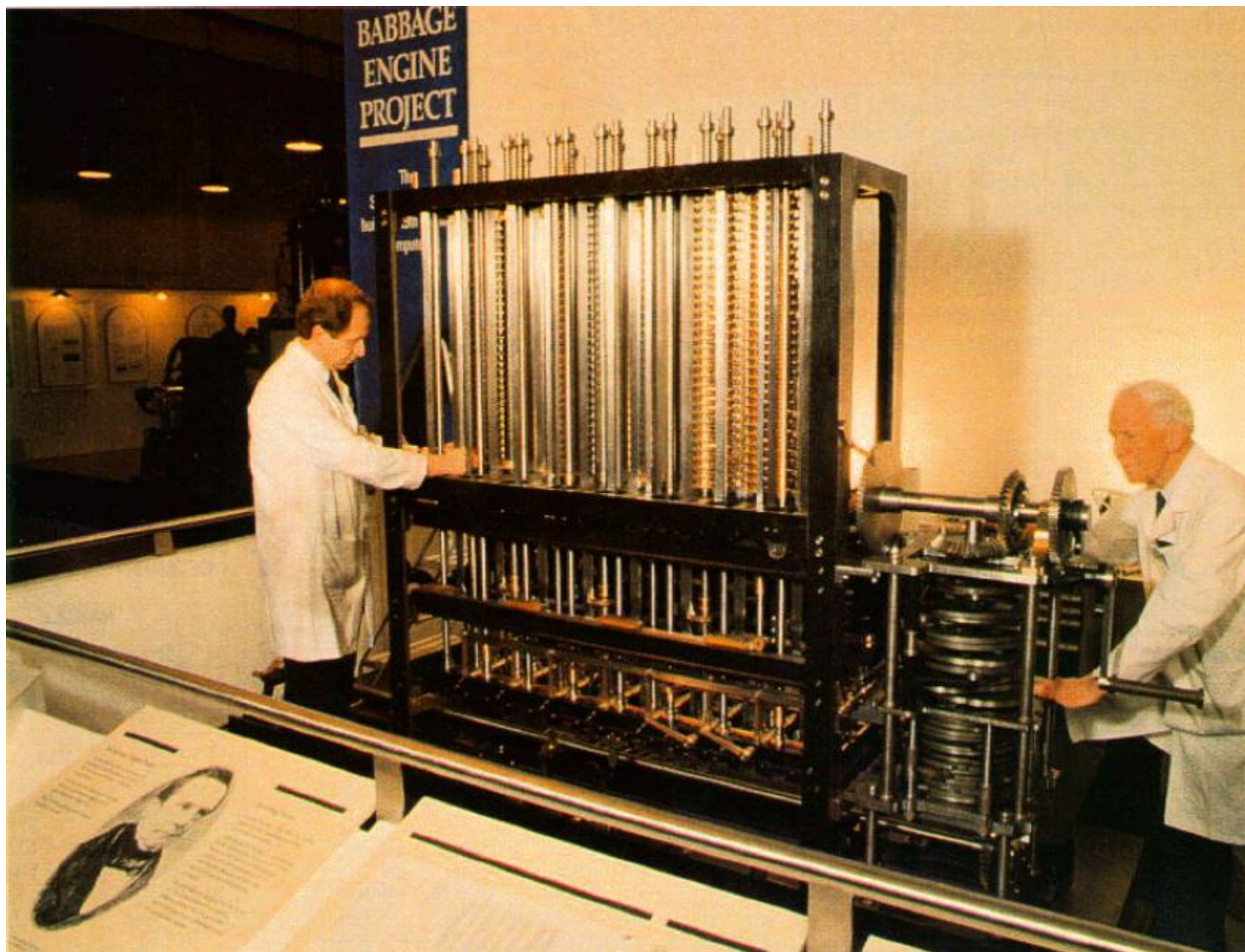
**“I wish to God these
calculations had been
executed by
steam.” (1821)**

Charles Babbage
1791–1871

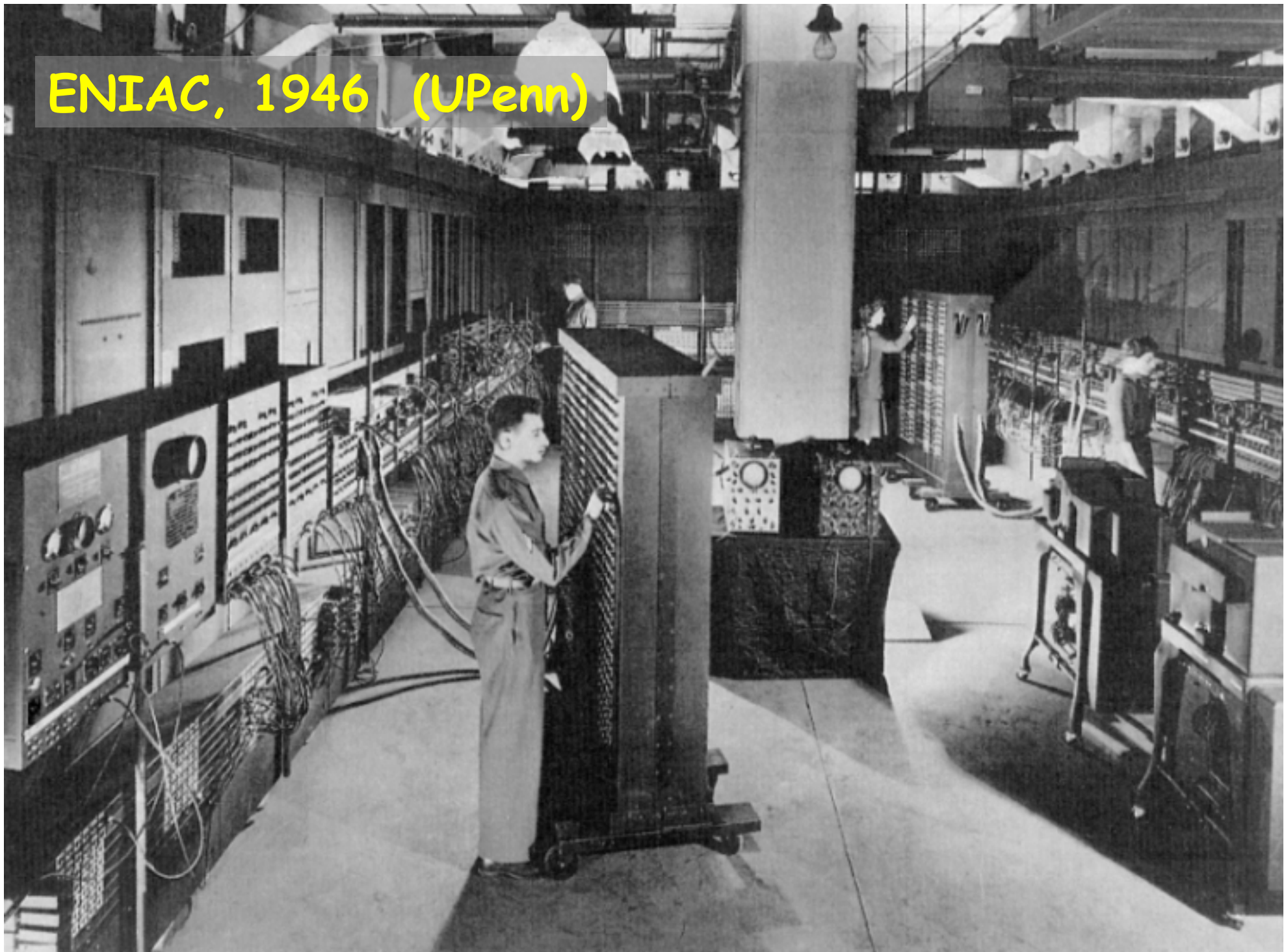
Ada Byron, Countess Lovelace

the world's first programmer?





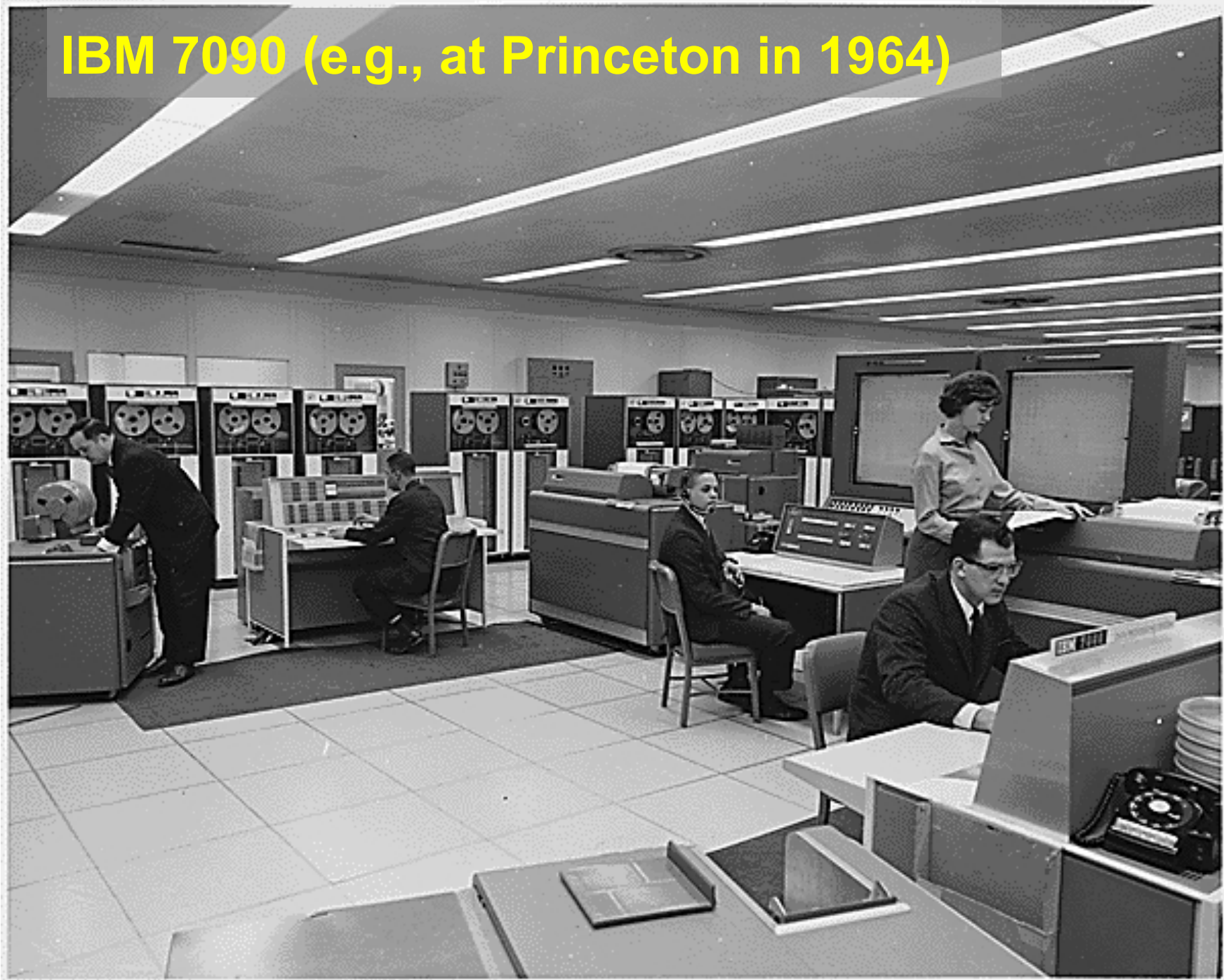
ENIAC, 1946 (UPenn)



John von Neumann and the Johnniac (1953)



IBM 7090 (e.g., at Princeton in 1964)

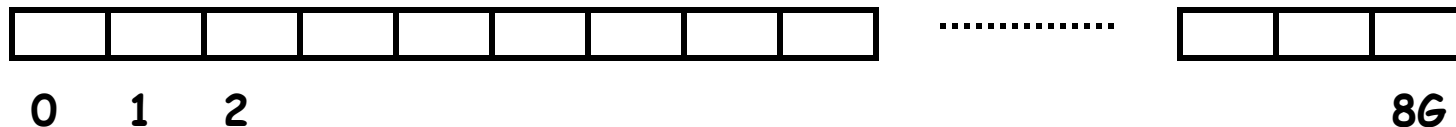


How fast is fast?

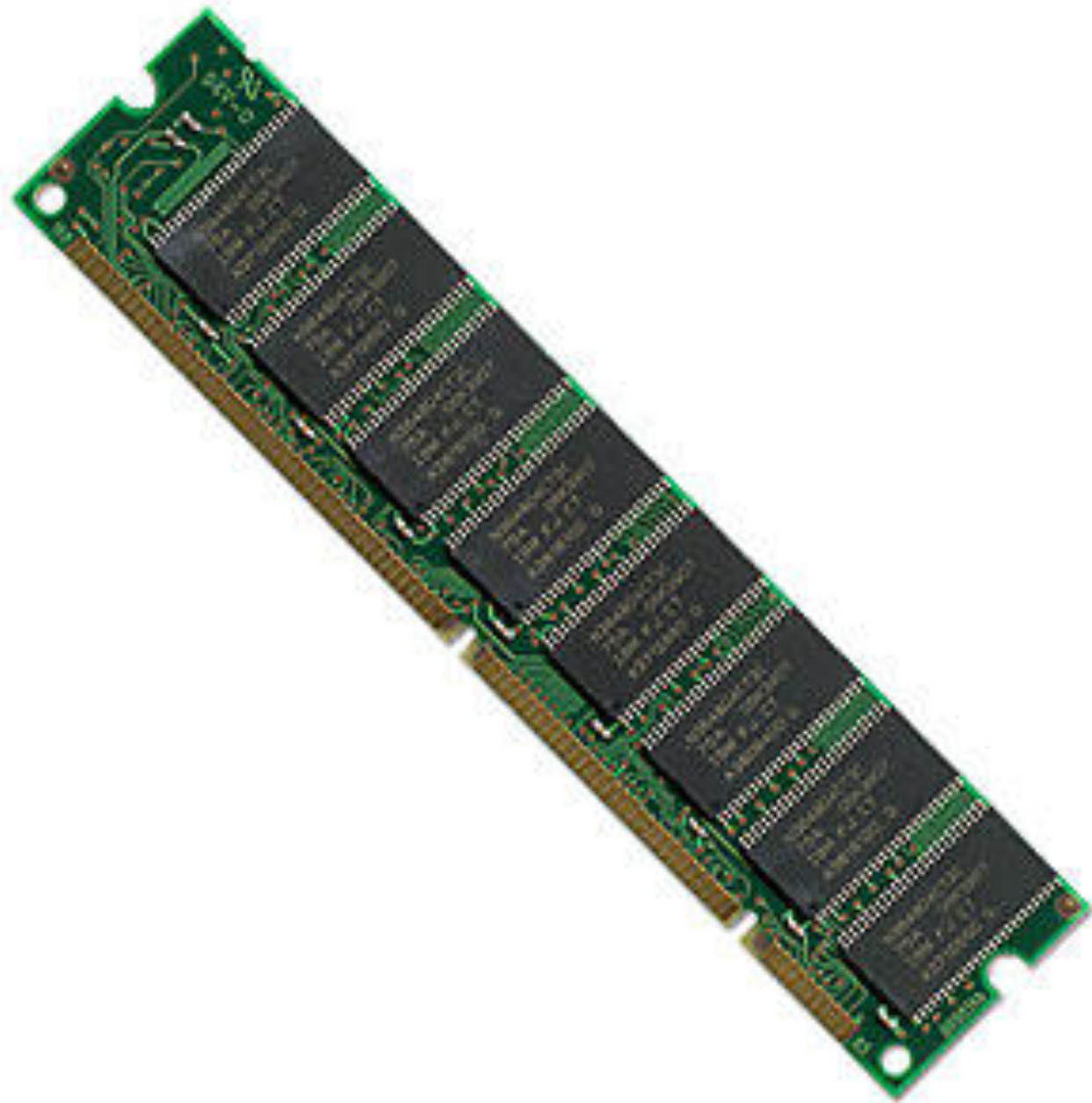
- CPU uses an internal "clock" (like a heartbeat) to step through instructions
- 900 MHz, 2.5 GHz, etc., is the number of clock ticks per second
 - 1 Hertz = 1 tick per second; abbreviated 1 Hz
 - mega = million
 - giga = billion
 - 1 MHz = 1 megaHertz = 1 million ticks per second
 - 1 GHz = 1 gigaHertz = 1 billion ticks per second = 1000 MHz
- one instruction (like adding two numbers) might take one, two or several ticks, depending on design of the CPU
 - might even complete more than one instruction in one tick
- modern processors execute several billion instructions/sec

Primary Memory (Random Access Memory = "RAM")

- a place to store information while the computer is running
 - the programs that are running
 - their data
 - the operating system (Windows, Mac OS X, Unix/Linux, ...)
- **volatile: forgets everything when power is turned off**
- **limited (though large) capacity**
- **logically, a set of numbered boxes ("pigeonholes"? mailboxes?)**
 - each capable of storing one byte = 8 bits of information
a small number or a single character like **A** or part of a larger value
 - random access
CPU can access any location as quickly as any other location



RAM

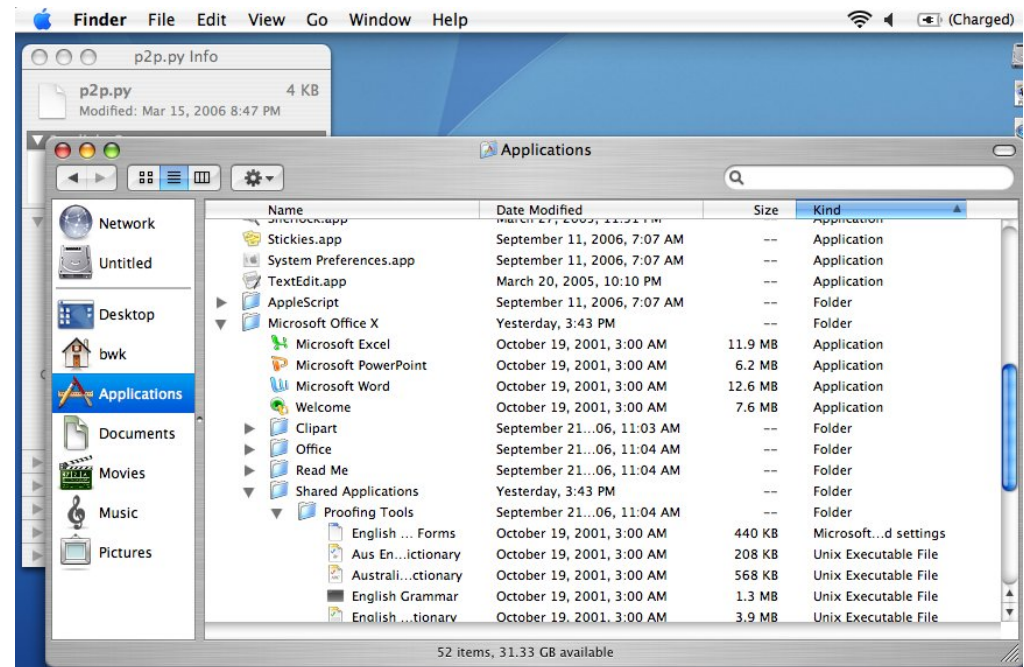


What's a bit? What's a byte?

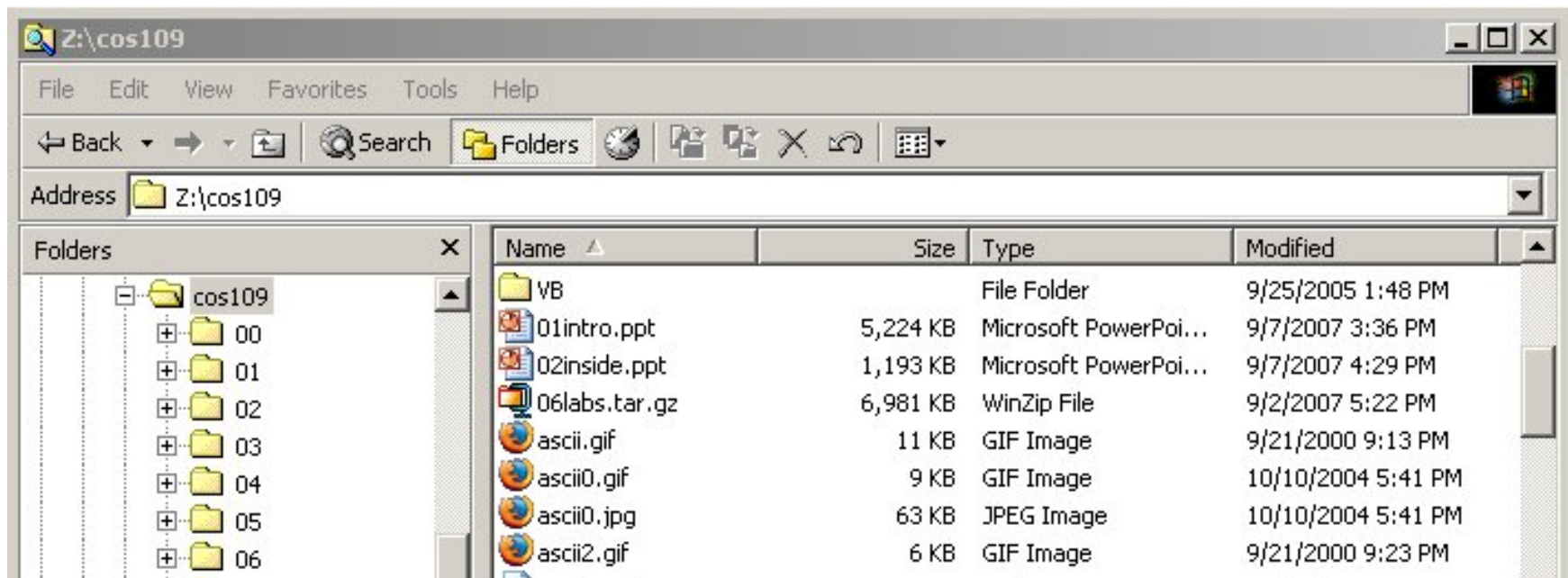
- a bit is the smallest unit of information
- represents one 2-way decision or a choice out of two possibilities
 - yes / no, true / false, on / off, up / down, ...
- abstraction of all of these is represented as 0 or 1
 - enough to tell which of TWO possibilities has been chosen
 - a single digit with one of two values
 - hence "binary digit"
 - hence bit
- binary is used in computers because it's easy to make fast, reliable, small devices that have only two states
 - high voltage/low voltage, current flowing/not flowing (chips)
 - electrical charge present/not present (Flash)
 - magnetized this way or that (disks)
 - light bounces off/doesn't bounce off (cd-rom, dvd)
- all information in a computer is stored and processed as bits
- a byte is 8 bits that are treated as a unit

Disks

- a place to store information when the power is turned off
- was based on magnetic surfaces, rotating machinery
 - today, more often solid-state Flash memory (SSD)
- **logical / functional structure: folders (directories) and files**
 - your information: papers, mail, music, web page, ...
 - programs and their data: Firefox, Word, iTunes, ...
 - operating system(s): Windows, MacOS, Unix, Linux, ...
 - bookkeeping info: where things are physically located

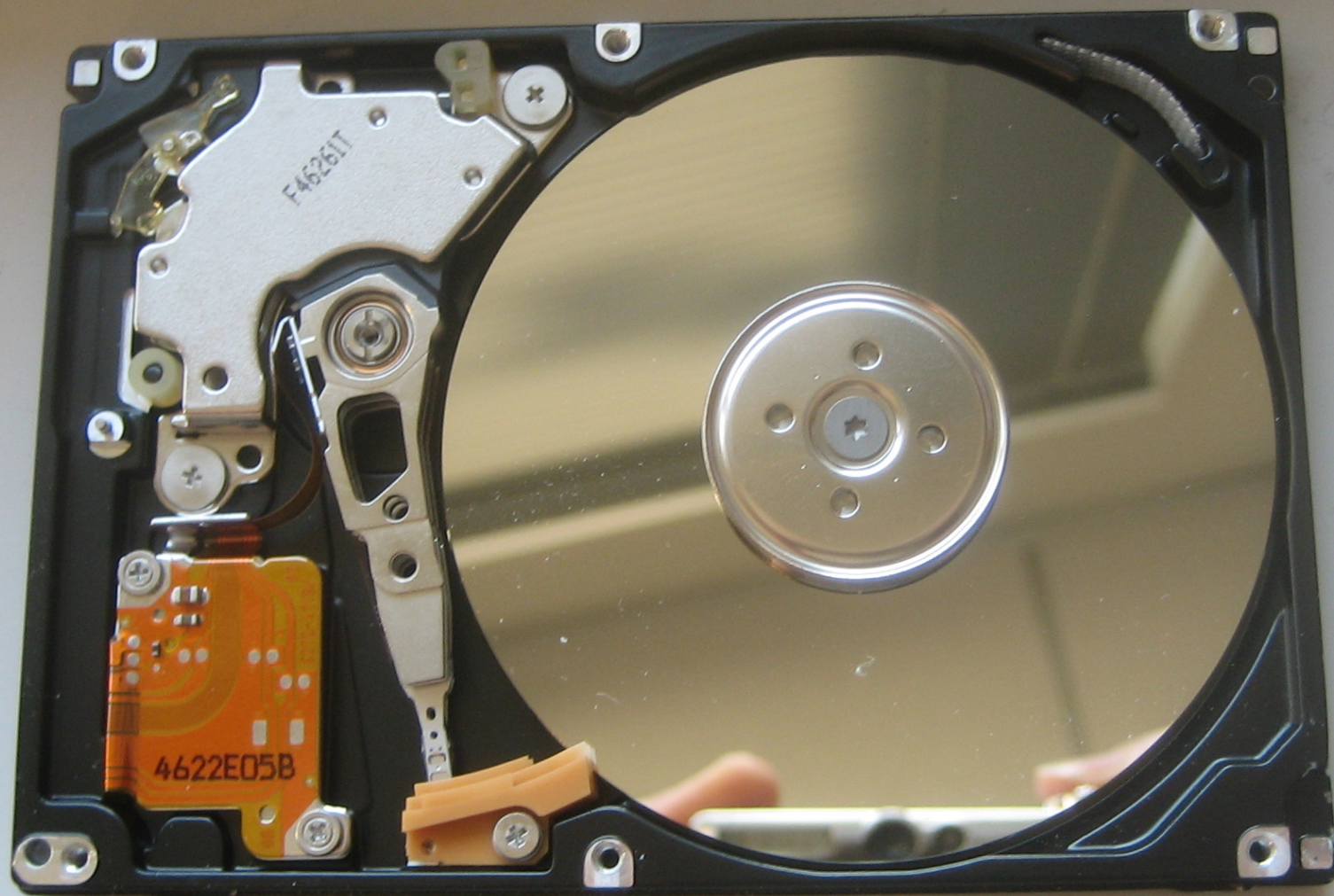


Other views of a disk: Windows, Unix/Linux



```
bash-3.00$ ls -ltr | tail -8
-rw-r--r--  1 bwk  fac    3283 Sep 19 08:10 survey.html
-rw-r--r--  1 bwk  fac 6034432 Sep 20 10:43 01intro.ppt
-rw-r--r--  1 bwk  fac    6870 Sep 20 10:54 ps1.html
-rw-r--r--  1 bwk  fac    2803 Sep 21 08:09 rita.09
-rw-r--r--  1 bwk  fac    7101 Sep 21 09:49 ideas.09
-rw-r--r--  1 bwk  fac    21766 Sep 21 13:55 index.html
-rw-r--r--  1 bwk  fac   143872 Sep 22 15:35 grades09.xls
-rw-r--r--  1 bwk  fac    3161 Sep 22 15:44 surveyresults.html
```


2.5" laptop disk



Wrapup on components

- the logical or functional components of computer hardware
- how they fit together, what the numbers measure
- some Greek/Latin/... prefixes:
 - (...,) nano, micro, milli, kilo, mega, giga, tera, (peta, ...)
- what the basic physical pieces look like
- one logical organization can have different physical forms
- logical organization hasn't changed much in 60+ years
- physical form has changed rapidly for the entire time
 - many tradeoffs among physical forms (size, weight, power, ...)

Some numeric prefixes you should know

nano	10^{-9}	billionth
micro	10^{-6}	millionth
milli	10^{-3}	thousandth
-	10^0	
kilo	10^3	thousand
mega	10^6	million
giga	10^9	billion
tera	10^{12}	trillion
peta	10^{15}	quadrillion

THE
YEAR
3000
(B.C.)

I'll still keep
a bunch of
rocks in my
basement, just
in case...



THERE IS MORE COMPUTING
POWER IN THIS LITTLE
ABACUS THAN IN ALL THE
GIANT ROCKS WE MOVE
AROUND TO DO
ADDITION.



oooooh!



rhymeswithorange.com
by Hilary "The Watch" Price 8-22