

Babylon

- Founded roughly 4000 years ago
 - Located near the Euphrates River, 56 mi south of Baghdad, Iraq
- Historically influential in ancient western world
- Cuneiform writing system, written on clay tablets
 - Some of those tablets survive to this day
 - Those from Hammurabi dynasty (1800-1600 BC) include mathematical calculations
 - (Also known for Code of Hammurabi, an early legal code)

CMSC 330: Organization of Programming Languages

A Brief History of Programming Languages

More about Algorithms

- Euclid's Algorithm (Alexandria, Egypt, 300 BC)
 - Appeared in *Elements*
 - Computes gcd of two integers

```
let rec gcd a b =
  if b = 0 then a else gcd b (a mod b)
```
- Al-Khwarizmi (Baghdad, Iraq, 780-850 AD)
 - *Al-Khwarizmi Concerning the Hindu Art of Reckoning*
 - Translated into Latin (in 12th century?)
 - Author's name rendered in Latin as *algoritmi*
 - Thus the word *algorithm*

A Babylonian Algorithm

A [rectangular] cistern.
The height is 3, 20, and a volume of 27, 46, 40 has been excavated.
The length exceeds the width by 50.
You should take the reciprocal of the height, 3, 20, obtaining 18.
Multiply this by the volume, 27, 46, 40, obtaining 8, 20.
Take half of 50 and square it, obtaining 10, 25.
Add 8, 20, and you get 8, 30, 25
The square root is 2, 55.
Make two copies of this, adding [25] to the one and subtracting from the other.
You find that 3, 20 [i.e., 3 1/3] is the length and 2, 30 [i.e., 2 1/2] is the width.
This is the procedure.

– Donald E. Knuth, *Ancient Babylonian Algorithms*, CACM July 1972

The number n, m represents $n \cdot (60^k) + m \cdot (60^{k-1})$ for some k

Alonzo Church (1903-1995)

- Mathematician at Princeton Univ.
- Three key contributions:
 - The lambda calculus (lectures in 1936, publ. 1941)
 - Church's Thesis
 - All effective computation is expressed by recursive (decidable) functions
 - Church's Theorem
 - First order logic is undecidable

The Analytical Engine (Babbage)

- Charles Babbage (1791-1871, London, England)
 - Developed a mechanical calculator, the Difference Engine
 - Like most developers, was overly eager so during 1830's developed plans for the *Analytical Engine*
 - Never completely finished
 - But plans only discovered in 1937
 - Built in 1991 at the Science Museum of London
 - Included branching, looping, arithmetic, and storage
 - Programmed using punch cards

Other Early Computers

- ABC (1939-1942)
 - Atanasoff and Berry Computer, at Iowa State Univ.
 - First electronic digital computer
 - As decided by a judge in 1973! (Invalidated ENIAC patent)
- Z3 (1945)
 - Konrad Zuse, essentially isolated from everyone else
 - Used Plankalkül, a sophisticated programming lang.
 - But no one knew about his results, so not influential

Alan Turing (1912 - 1954)

- The father of modern computer science
 - Dissertation work advised by Church at Princeton
 - Formulated the Turing machine (~1936) (A more general form of abstract computer. We've already looked at simpler versions like DFA and PDA)
 - Σ – A finite alphabet
 - Q – a set of states
 - $s \in Q$ – A start state
 - $F \subseteq Q$ – The final states
 - $\delta : Q \times \Sigma \rightarrow Q \times \Sigma \times \{L, R\}$
 - If $\delta(q, a) = (q', a', d)$, then if we're in state q and see a on the tape, then replace it by a' , move to state q' , and move the position of the tape either left or right
 - A formal definition of a computable algorithm

The First Programming Languages

- Early computers could be “programmed” by rewiring them for specific applications
 - Tedious, error prone
- John von Neumann (1903-1957)
 - Three CS contributions (famous for lots of other stuff)
 - von Neumann machine – the way computers are built today
 - A *stored program architecture*
 - » Program stored in memory as data, so can be modified
 - (Unclear that he actually invented this...)
 - “Conditional control transfer” – *if* and *for* statements
 - Allows for reusable code, like subroutines

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Other Early Computers (cont'd)

- Harvard Mark I (1944)
 - Aiken, IBM
 - Electronic, used relays
- ENIAC (1946)
 - Electronic Numerical Integrator and Computer
 - Developed by Eckert and Mauchly at UPenn
 - Electronic, general purposes
 - Used vacuum tubes
 - For 30 years considered the “first” electronic computer until court case gave honor to ABC. Supposedly Eckert and Mauchly overheard Atanasoff discussing designs for ABC.

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FORTRAN (1954 - 1957)

- FORMula TRANslator
- Developed at IBM by John Backus et al
 - Aimed at scientific computation
 - Computers slow, small, unreliable
 - So FORTRAN needed to produce efficient code
- Features (FORTRAN I)
 - Variable names (up to 6 chars)
 - Loops and Arithmetic Conditionals
 - *IF (ICOUNT-1) 100, 200, 300*
 - Formatted I/O
 - Subroutines

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Pseudocodes (Assembly Interpreter)

- Short Code (1949)
 - John Mauchly
 - Interpreted instructions
 - E.g., *X0 = sqrt(abs(Y0))* becomes *00 X0 03 20 06 Y0*
 - *06* = abs, *20* = sqrt, *03* = assignment
 - But needed to translate by hand
- A-0 Compiler (1951; Grace Murray Hopper)
 - Translated symbolic code into machine code
 - Sounds like an assembler...
 - Assigned numbers to routines stored on tape
 - Which would then be retrieved and put in memory

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