



# **“COMPUTER SAYS NO” - IS THERE ANYTHING THAT COMPUTERS TRULY CANNOT DO?**

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# Our cultural heritage: Theory of computation

- G.W. Leibniz's dream: When in doubt philosophers should say "Calcuemus!" and settle matters by "rational means" (the "calculus ratiocinator").
- D.E. Knuth: "Science is what we understand well enough to explain to a computer. Art is everything else we do."
- One of the key (philosophical) questions for mankind: **What problems can be solved scientifically?** (See Immanuel Kant's "Critique of Pure Reason".)

## A widely held belief

- “Put the right kind of software into a computer, and it will do whatever you want it to. There may be limits on what you can do with the machines themselves, but there are no limits on what you can do with software.” (TIME magazine, 1984)
- Wrong! Computer scientists have been investigating the limits of computational models of all kinds since the 1930s. Such investigations are a unique intellectual achievement!
- Computational laws capture the limits beyond which computations are “impossible”. Examples?

Some exhibits: “Dear members of the jury....”

- **Unsolvability:** “Can one find out whether a mathematical statement is true or false?” “Does this computation terminate?”
- **One can't do better:** “Can one efficiently determine whether some pedigree data are consistent?” → “Can ‘creativity’ be automated?” (NP-completeness)
- **Impossibility:** “Can group agreement be reached using email communication if one of the agents is ‘faulty’”?
- **Lots more!** (Read “Computers Ltd: What they really can't do” by David Harel. *Harel woz 'ere!*)

# Why Impossibility?

- To satisfy intellectual curiosity.
- To discourage futile efforts.
- To encourage development of new paradigms, e.g., parallelism, randomization, heuristics, and quantum computing.
- To make possible the otherwise impossible!
  - Cryptography (“secure shopping on the internet”)
  - Zero knowledge (“convincing someone you know something without saying what it is”)
  - Anonymous electronic voting
  - Checking the correctness of a 100-page mathematical proof by looking only at a few lines
- **Take-home message:** “....the things that cannot be known, that cannot be done, and cannot be seen, define our Universe more clearly, more completely, and more sharply than those that can.”  
(John D. Barrow)



# Computer says NO!

- <http://www.youtube.com/watch?v=U0bHkXHLSt0>