

Building the Pascaline: Digital Computing Like It's 1642

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Significance and Relevance: “Maker culture” and the spread of rapid prototyping tools in universities and high schools is a significant trend in technology education. This poster illustrates an important consequence of this trend: using laser cutters or 3D printers, CS educators can now easily create physical artifacts to help students explore computational ideas.

Content: The poster will briefly review how the Pascaline works and then present my implementation, which I've developed into an inexpensive open source kit. High school or college students with minimal skills can assemble the kit and have a working calculator. (Students in my Rapid Prototyping Technologies class at CMU did so this semester.) The remainder of the poster will focus on how the Pascaline replica can be used as a teaching tool to explore important theoretical concepts in computation. More details are given in the abstract.

Abstract:

The Pascaline was the first working mechanical calculator, created in 1642 by the French polymath Blaise Pascal. Over the next two decades Pascal built 40 of these machines, of which nine survive today. Several good web resources describe the Pascaline, but to properly appreciate the sautoir, Pascal's kinetic energy solution to jam-free ripple carry, a working replica is invaluable.

Since computer science students typically have limited fabrication skills, I've created an accessible Pascaline kit. The design constraints were: no user cutting or drilling, no glue, no set-screws, and parts must be fabricable on the most basic laser cutter. The kit uses 1/8 inch acrylic, standard fasteners, and Loctite. It can be assembled (and disassembled) with a screwdriver and pliers.

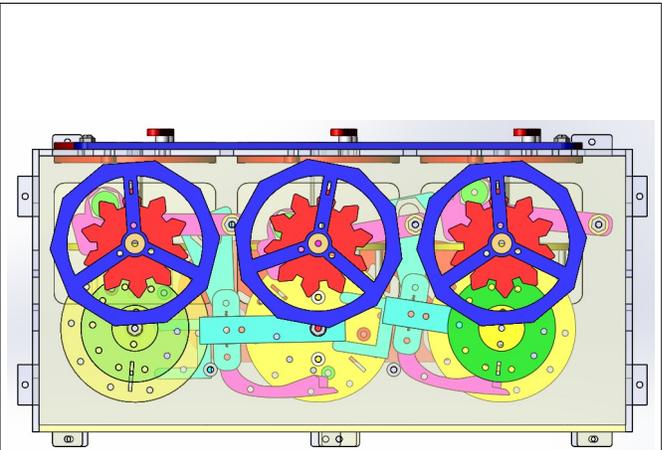
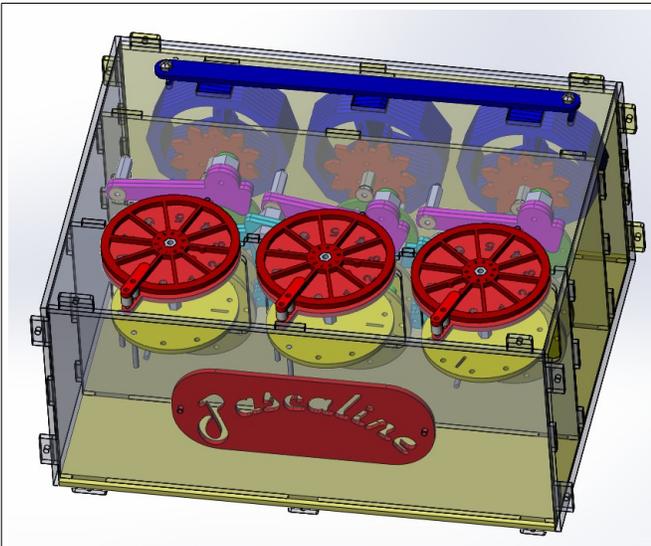
Exploring the Pascaline is an engaging way to connect a milestone in the history of computing to modern theoretical concepts. Students can investigate questions such as: What makes a device "digital"? (Slide rules have numeric scales but are analog devices.) How does nonlinearity produce discrete states in a continuous world? How are nonlinearities induced in the Pascaline vs. in digital electronics? How do the logic design concepts "half adder" and "full adder" map onto the components of the Pascaline? Is the Pascaline really adding, or just counting? How does the Pascaline use nines complement arithmetic to perform subtraction, and why isn't it tens complement?

The kit, designed in SolidWorks, is open source and available on the web at <http://www.cs.cmu.edu/~dst/Pascaline>.

One of Pascal's original machines:



My Pascaline replica:



Rear view showing the sautoir mechanism.

