Specializing in Novel Problems Using Theory And Prototyping

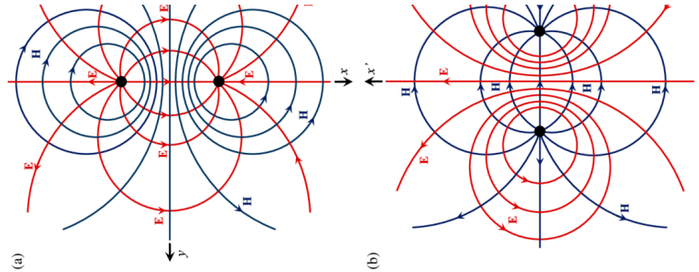
There is a powerful method for bringing new ideas into the world that is not taught in any university. It is built on a broad base of theoretical knowledge and the ability to explore new areas through prototyping. It extends the abilities of designers, engineers, architects, technical artists, or anyone creating functional work. Because theoretical knowledge and prototyping extend the range in which one can perceive opportunities and solve problems.

It's like being able to specialize in things that have never been done before.

This graduate curriculum is a counterpoint to the maker programs at many universities. The maker movement has been a positive revolution. But the world around it has changed. Skills that once made one a wizard are now common. The low-hanging fruit is picked over. And the new frontiers require a depth and breadth of knowledge few have.

I see this gap because I have been hiring and training assistants for ambitious projects since 2010. So many applicants have used an Arduino or a laser cutter. But so few understand anything about geometry, electricity & magnetism, shop tools, algorithms, digital logic, materials, software, etc. The most successful hires have been able to think articulately and quantitatively about the concepts underlying each challenge, impasse, or blank space. And they have had the skills needed to create and test their ideas.

I want to bring this training to a university.



Theory

Theory is more powerful than many other types of knowledge. With theory, we see more deeply into the world. More connections, more patterns, more opportunities. We can resolve the world as equations, algorithms, circuits, geometries, and more.

So we will learn a broad bedrock layer of fundamental knowledge about math, physics, algorithms, analog and digital circuit design, software engineering, and the connections between them.

This sounds like a lot of material. But most of it could be found in the freshman courses for a range of subjects. It's not too challenging for a grad program. And few students get the opportunity to learn the breadth of it.

And unlike learning specific tools or programs, fundamental theory rarely becomes obsolete.

Novel problems are more solvable when they are adjacent to subjects we know well. And this bedrock of fundamental theory touches a vast area of higher subjects.

Prolific Prototyping

Prototypes are for exploration.

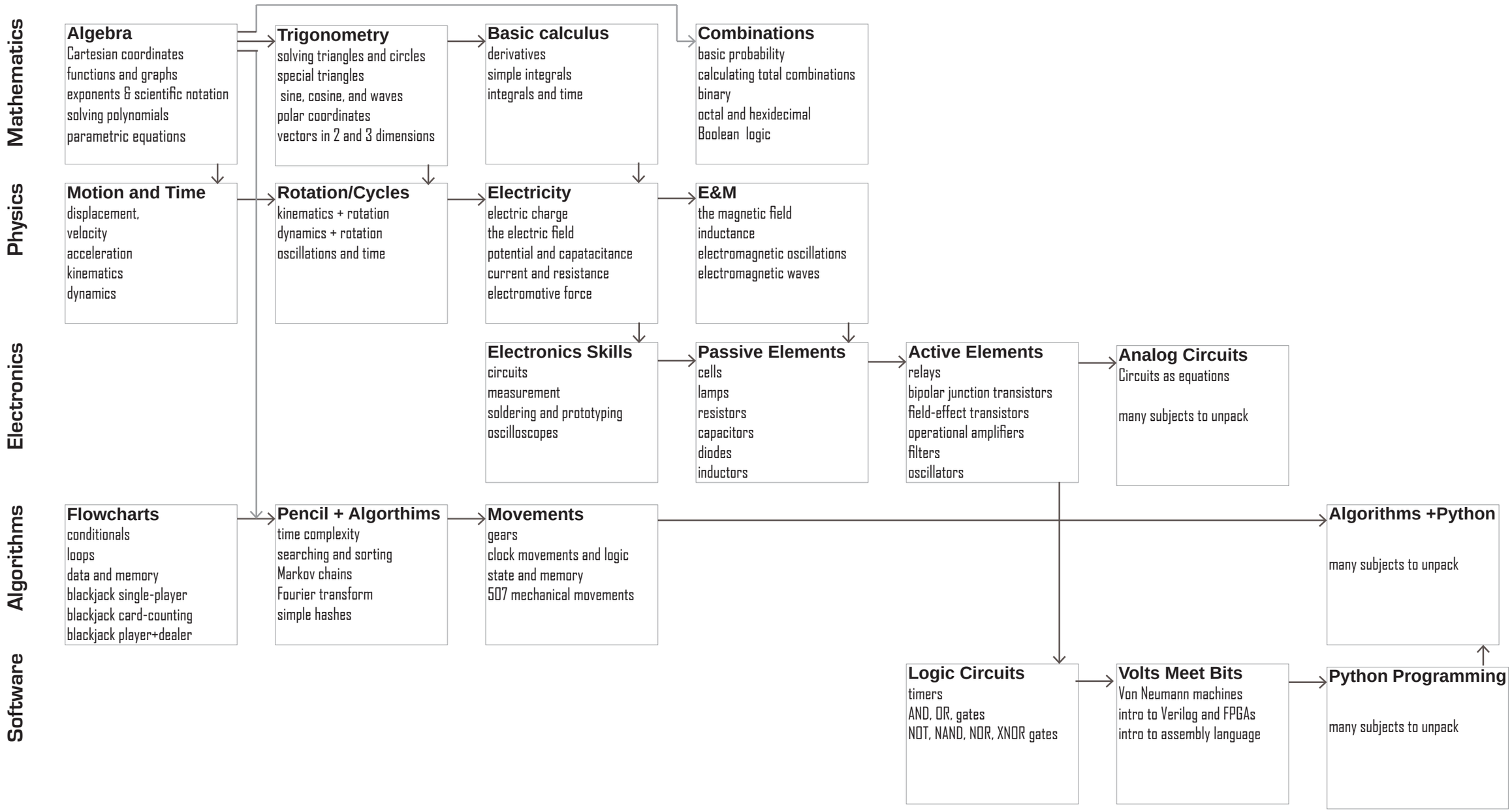
In many fields, a prototype is an early version of a product. But in this discipline, prototyping is an ongoing process for discovering the landscape of impasses and opportunities in an uncharted territory.

We will build prototypes quickly and constantly. Once we are skilled, most can be finished in less than a day. All prototypes are successful if they are informative. And they often answer additional questions we have not yet thought to ask.

Learning to make effective prototypes this quickly requires many new skills in design and fabrication. But there is no faster way to develop an intuitive sense of a new territory than to have functional prototypes to test and play with.

Days in the curriculum will combine formal instruction with independent design, prototyping, and problem-solving. New prototypes will be due every few days.

Theory Topics and Dependencies



Prototyping Topics and Dependencies

Prototyping

Prototypes are Tests
differences between design and technology
mixing high and low precision components
designing for fast fabrication
techniques for 1-day prototypes
finding success in 'failed' prototypes

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Designing Systems
Inspiration, Constraints, Iterations
Top-down design and its limitations
Bottom-up design and its limitations
Convergence Diagrams
Discovery-oriented design

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Troubleshooting Techniques
structured troubleshooting
magic bullet vs. Higgs boson
induction, capacitance, invisible influences
most problems are electrical connections

CAD and modeling
3D Concepts
CAD Concepts
FreeCAD or Fusion360
Blender

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Using Tools

Safety and First Aid
No exceptions
Appropriate clothing
Personal protective equipment
Treating minor wounds
Treating minor burns

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Using Hand Tools
measurement and precision
wrenches & pliers
snips, saws, cutters, & knives
striking tools & struck tools
drivers
vises, clamps, drills

→

Using Machine Tools
table/band/circular/chop saw
lathe
milling machine
electric drills/drivers & dril press

→

Power Transmission
gears
belts and pulleys
chain and sprockets
rotary motion
linear motion
complex / logical movements & horology

→

Using CNC Tools
router
mill
3D printer
laser cutter
wire bender

Materials

The Palette of Materials
strengths, sources, chemistry, aesthetics
stone
leather
woods
metals
plastics
ceramics / glass / concrete
fibers and fabrics
biomaterials

→

Working With Woods
types of woods
elasticity and grain
cutting
types of joins
finishing

→

Working With Metals
types of metals
thermal expansion
precision
cutting
welding
casting
finishing

→

Working With Plastics
variety of properties
cutting
joining / adhesives
casting
finishing

A Few Example Exercises

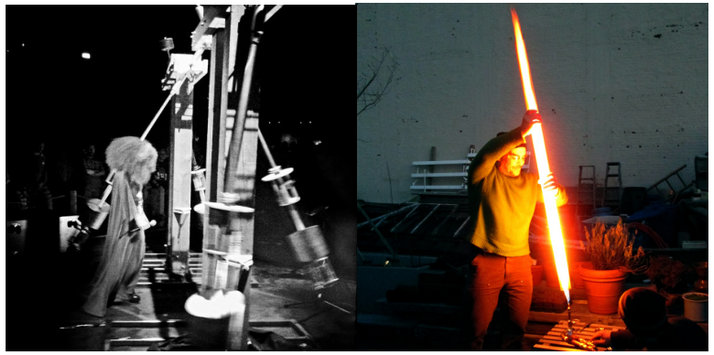
In addition to topic-specific assignments and personal projects, students will practice integrating multiple topics and skills. Some exercises will require creating functional representations of algorithms in new mediums as we acquire new skills. These exercises will also provide practice with math, design, and fabrication. The table below shows a quick first draft of the types of mediums and algorithms that might be combined.

Other exercises might include:

build a binary abacus
build DIY logic gates with non-electronic components
build circuits as expressions of math functions
build a simple synthesizer

algorithm	flowchart	cards dice	mechanical movements	logic gates	verilog/ FPGA	Assembly Language	C	Python
single-player blackjack	●			●	●	●	●	●
player/dealer blackjack	●							●
player/dealer/betting blackjack	●							●
card counting blackjack	●							●
search/sort (various)	●	●	●			●	●	●
winning tic-tac-toe	●		●	●	●			●
8-bit binary adder		●	●	●				
8-bit memory			●	●				
8-bit to base 10				●				
8-bit to base 10		●	●	●				
simple hash	●	●	●		●			●

Andy Cavatorta Studio



Andy Cavatorta Studio specializes in ambitious projects unbounded by categories. Fine arts commissions, mobile robotics, opera set design, kinetic sculpture, product design, musical instruments, software platforms, game design, R&D, and whatever comes up next.

Clients include Björk, the MIT Museum, Royal Opera House (London), Oslo Opera House, MoMA, the central bank of Mexico, Barney's, Pierre Huyghe, and many more.

Andy Cavatorta is the creative and technical principal of Andy Cavatorta Studio.

Two good examples of his theory + prototyping methodology can be found here:

https://andycavatorta.com/irvine.html
https://andycavatorta.com/gravityharps.html