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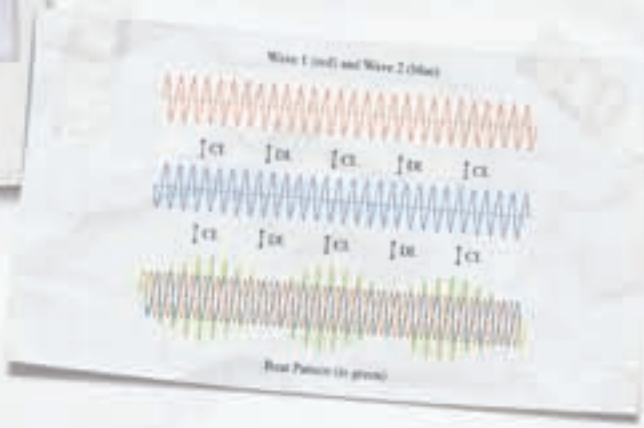
MAKE A TREASURE FINDER.

In a simple coil-oscillator circuit, the frequency of the oscillations depends on the coil's size and how many turns it has. More turns make current in the coil slower to reverse, lowering the frequency. Moving metal objects close to the coil also lowers the frequency, because it adds more electrons sloshing back and forth in the coil's constantly reversing magnetic field.



Take a deep breath and imagine that you are on a desert island with buried treasure. (Or if that's a stretch, just imagine that you like to find lost coins, jewelry and other artifacts around town or at the beach.) All that you have to assist you is a shovel, a home workshop and the island's RadioShack store.

How do you find the treasure? You can't see it, and it probably isn't magnetic, so you need to rely on other properties. Most treasure contains solid metal, so you can try to find things that are conductive. The free electrons in a conductor react to and affect a surrounding electromagnetic field, even through the ground. That's a start—so now you need a way of detecting this behavior.

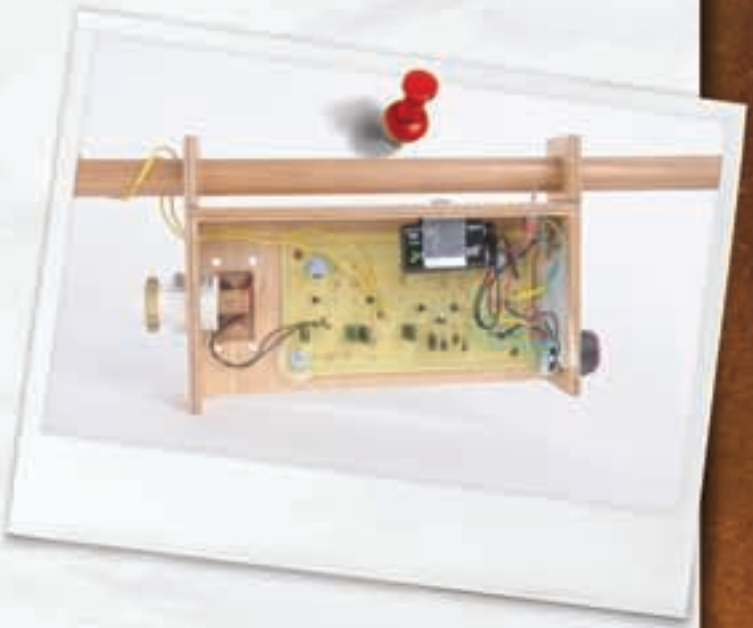
So a coil circuit will change its frequency in close proximity to metal, but the change is usually too small to hear. To make it more obvious, a second oscillator circuit with a manually tunable coil can act as a reference oscillator. Tune the reference to match the detector. Very slight changes in the detector frequency will result in an easily heard beat frequency, as the two tones cyclically reinforce and cancel each other out. (The beat frequency equals the difference between the two frequencies.)

Connect headphones or a speaker, add a handle for moving the detector over the ground, and you're ready to hit the beach in search of treasure.

To make your own treasure finder, you need plywood, a broom handle, some electronic components and a few other easily sourced parts.

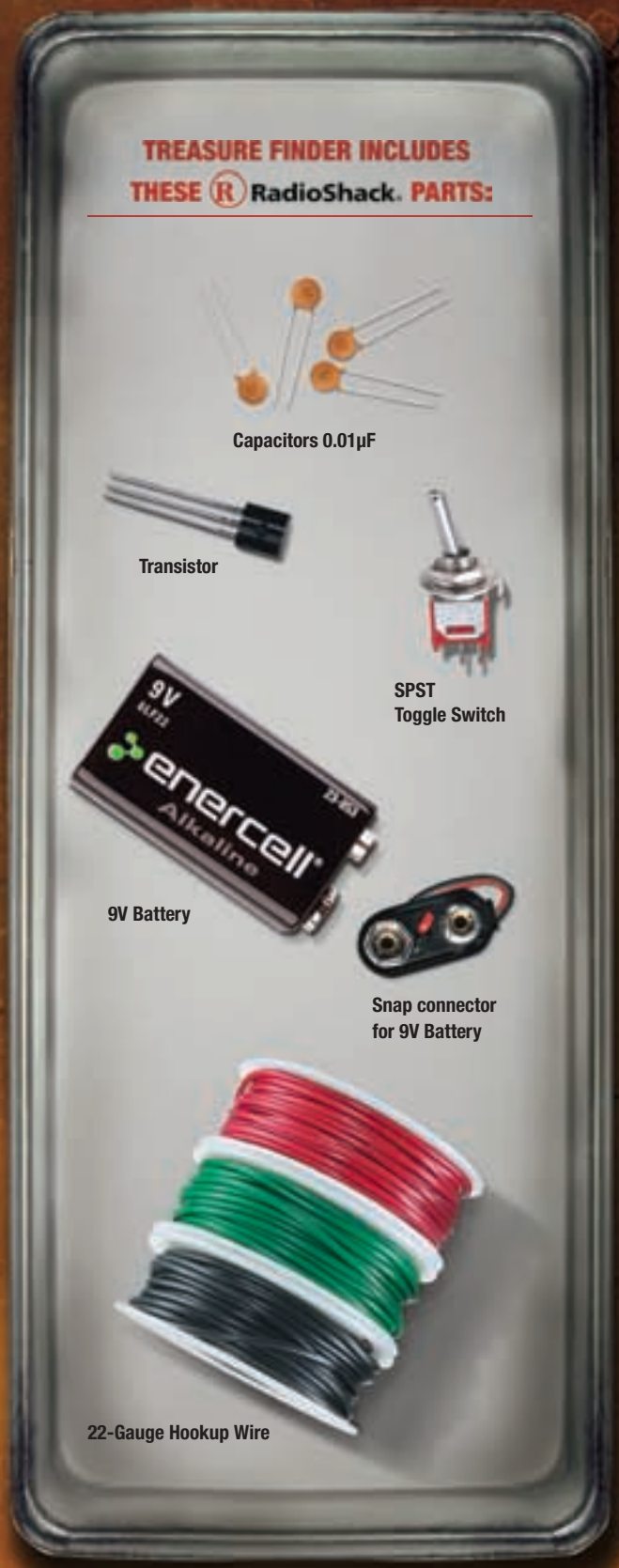
By Paul Spinrad & Steve Hobley

See how it's made at:
RadioShackDIY.com/TreasureFinder.



PARTS:

- ☐ Resistor assortment, 1/8 watt 500 pieces
- ☐ Capacitors, 0.01µF (5)
- ☐ Capacitors, 220µF electrolytic (2)
- ☐ Magnet wire, 26-gauge
- ☐ Transistors, NPN, 2N3904 (6)
- ☐ 22-gauge hookup wire
- ☐ Speaker wire, 4'
- ☐ Speaker, small, 8Ω
- ☐ Switch, SPST toggle
- ☐ Headphones, 1/8"
- ☐ Battery, 9V
- ☐ Snap connector for 9V battery
- ☐ Potentiometer, 5KΩ, audio taper (optional)
- ☐ Audio jack, 1/8", mono, panel mount (optional)



To submit your own creation, explore other great creations and get the hard-to-find parts you need, visit RadioShack.com/DIY

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Why Are We Crazy for Kits?

BY KEITH HAMMOND

This special issue of MAKE is all about kits, and the promise behind each kit that you can make something cool. Why?

Kits are the gateway DIY project. Words can't describe the pride a 9-year-old feels when he glues the final piece atop the enormous Apollo Saturn V moon rocket model he built with his dad (Thanks, Dad!) and takes it to show-and-tell at school. *I made this!*

For many of us, a kit is the first thing we remember making — whether Lego or Erector sets (see page 18), needlepoint or paint-by-number, or model planes and cars from Testors and Revell. The excitement can be enough to set us on a path of creative making for life. Who knows what doors you're opening when you put a kit in the hands of a beginner?

Kits teach skills. When you make a kit, somebody has done you a great service — designed it, gathered parts, illustrated instructions — so you can focus on the good stuff: mastering the skills required to make the thing, and understanding how it works.

Handmade beats store-bought. Pink Snuggie blankets come and go, but Grandma's crocheted afghan is forever. Psychologists call this the Ikea Effect — adding our personal labor just makes the thing more valuable.

Making something is more fun than buying it. Kits quick-start the fun.

Kits are exciting and mysterious. If you don't know how to make it from scratch, then the kit is your path into the unknown, to new knowledge that's empowering, maybe even dangerous (just ask Wile E. Coyote about ACME kits).

Like Alice's "Drink Me" bottle or Neo's red pill, the kit is a portal to an experience you may or may not be ready for. And if it's mysterious to you, imagine how deliciously mystifying it must be to those around you. *What is he building in there?*

Kits are great for sharing. Kids and parents can build a starter kit on an equally clueless footing, learning together.

Kits open up community. Build a kit and you're joining a group of people who've built it too, and are no doubt trading tips and showing off their builds online. You're smarter thanks to the pack, and you're meeting makers who share your excitement.

Kits drive innovation. When a kit sells well, suddenly there are people in every town building newfangled TV sets (remember Heathkit? they're back, see page 24) or aerial Arduino robots (check out DIY Drones, page 26). Like seeds in the wind, those kits switch on thousands of new makers, who become a community of innovators, excited and hungry for more advanced kits and products, in an upward spiral.

MIT's Michael Schrage looks into the phenomenon (page 8) and finds that kit-makers have driven the great technology upheavals, from Boulton & Watt's steam kits in the Industrial Revolution, to Woz and Jobs' Apple I kits in the computer revolution (build a replica, page 41).

I remember my dad's excitement building kit computers in the 1970s, little boxes programmed in hex code via a 10-key pad, no video, just 7-segment red LEDs for a readout. A kit in the mail challenged him to build his skills, raised his expectations of computers, and fired his imagination about what could be done with them. Once he'd mastered a kit, he wanted the next most advanced kit, and then the first home computers (Apples, Ataris, Commodores), and so on.

Multiply that fired-up kit maker by thousands and you've got a smart, skilled, hungry community experimenting with new technology, and bringing along their friends (and their kids — my sibs and I were 10, 11, and 13, programming in BASIC).

History repeats. Today we're watching the same innovation explosion unfold in 3D printing, DIY robotics, and microcontrollers, as skilled amateurs build kits and hack them, egg each other on, and teach those around them.

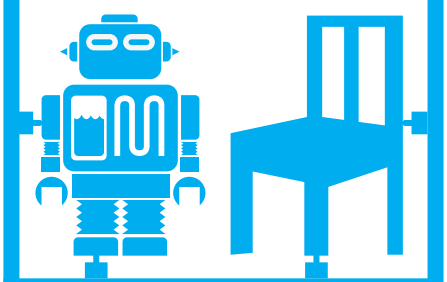
The next Steve Jobs is out there, building kits.

Keith Hammond is Projects Editor of MAKE. He wanted to be an astronaut.

Make: SPECIAL ISSUE

ULTIMATE KIT GUIDE

175+ DIY KITS REVIEWED



KIT CRAZY

FEATURES

KIT REVIEWS

Juan Leguizamon

"When I was a kid, both my dad and the Heathkits made me believe I could build anything."
—Steve Jobs

Make: technology on your time

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Bringing the Best Kits to Makers

BY DAN WOODS

BACK IN OUR FIRST YEAR, the Maker Shed shipped more than 25,000 kits. Not a bad start, but after years of steady growth, we shipped 105,000 units last year.

Why this upswing in kit interest? Part of our success is the result of a smart team that uncovers beautiful kits that resonate with our audience of makers and science enthusiasts. However, I think the data is also telling us about the value we all derive from a good hands-on project.

Perhaps it's focusing on something we can control when so much around us is uncontrollable. Maybe it's the satisfaction of picking up a new skill, dusting off an old one, or simply learning how something works (or doesn't). Maybe it's the memories that live on long after you're done.

And there's definitely something intrinsically satisfying about passing along skills to a younger maker. What kid doesn't enjoy a workbench, a few tools, and a good project on a rainy day?

Economically, times are tough, but our basements and backyards are coming alive with experiments, tinkering, and the maker spirit. So this holiday season, whether you provision a project from materials lying around the house, or decide to buy a project kit from the Maker Shed or elsewhere, give yourself and someone you care about the gift of making something together.

LOOK FOR OUR "MAKER MADE" SEAL OF RECOGNITION FOR OUTSTANDING KITS

After years of combing the planet for awesome kits created by independent makers, we decided to create our own form of recognition. We're excited to announce MAKE's very own "Maker Made" seal of recognition for kits that the MAKE staff find particularly awesome. Whenever you see this badge next to a kit, just know it was created by an independent maker, and we think it deserves special props.

LOOKING FOR A FEW GOOD KIT MAKERS

Meanwhile, we're expanding our line of kits — and we want to meet new kit makers.

Ever had a cool idea for a kit but weren't sure how to bring it to market? Or maybe you're already selling kits but you'd like to expand your reach. Breaking into the market can be daunting for independent makers.

We love to help makers get started with kit making and bringing them to market. We're willing to take risks on promising small runs, often hand-assembled by makers in their own workshops. This is how we started, how we built our business, and what keeps us different. If you have a kit you're about to launch or even a kit design you're not sure how to develop, we'd love to hear from you.

We curate kits for a range of interests and experience levels, and are particularly interested in robotics, electronics, microcontrollers, ballistics and aeronautics, servos and motors, smart materials, crafts, and anything that engages kids. We love kits that work well in classrooms, camps, hackerspaces, even birthday parties! Ideal kits are inspirational, educational, include everything you need to get started with helpful documentation, and encourage exploring more than one outcome.

Interested in getting your kit in front of millions of makers? Send a note to kits@makezine.com and tell us what you have in mind. We keep the process friendly, down to earth, and straightforward.

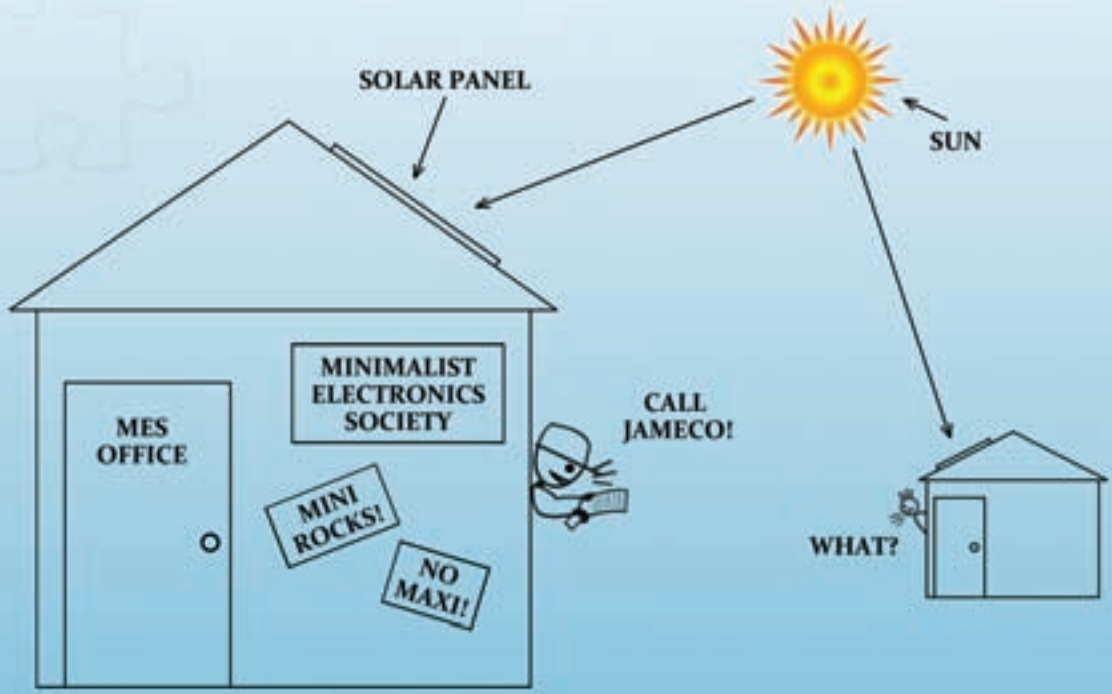
TOP-SELLING MAKER SHED KITS IN 2011

1. MINTRONICS SURVIVAL PACK MSTIN2
2. MAKERSHIELD KIT MSMS01
3. MAKE: ELECTRONICS COMPONENT PACK 1 MECP1
4. GETTING STARTED WITH ARDUINO KIT MSGSA
5. LEARN TO SOLDER SKILL BADGE KIT MKLS01

Available at: makershed.com

Dan Woods is MAKE's associate publisher and general manager of e-commerce. When he's not finding cool new stuff, he likes to hack and build barbecues, smokers, and outdoor grills.

Can You Solve This?



Consultant Ed Brown was retained by the Minimalist Electronics Society (MES) to design an electronic intercom that would allow the group's president and secretary to speak to one another between the two tiny structures that served as their offices. The only condition was that the intercom must be as minimalist as possible. A conventional intercom would require a pair of conductors, which was one too many. The soil under the offices was desert gravel and much too dry for linking the offices with a single wire and a ground at each end. Cell phones or radio? No way. Their signals would be sprayed everywhere, thereby violating minimalism. Power line link? No. Each office was powered by its own roof top solar panel. Brown finally thought of a solution. What's yours? Go to Jameco.com/unknown12 to see if you are correct.

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ESSAY

Kits and Revolutions

An MIT economist's lesson in Kitonomics 101. BY MICHAEL SCHRAGE

The Industrial Revolution began with kits. In 1763, Glasgow University's scale model Newcomen steam engine broke, so the physics professor asked the school's resident mechanic to fix it. A talented instrument maker, this university employee didn't just get the machine working again, he figured out a clever way to improve the design by turning a surgical syringe into a piston and condenser.¶ That Scottish mechanic was James Watt, and he partnered with Birmingham, England's Matthew Boulton to commercialize the design. But rather than producing finished steam engines for the coal mines and breweries that used steam power, they sold engineering "kits" — with extensive instructions — that required on-site assembly. Boulton & Watt made a killing, and transformed their age.

This rough template has foreshadowed technological revolution ever since. Whether in radio, auto, aircraft, electronics, or personal computers and the internet, communities of kit-building talented amateurs — not credentialed elites — have disproportionately influenced early innovation. The proliferation of cheap kits better signals a market sector ripe for revolution than the presence of expensive "cutting-edge" products.

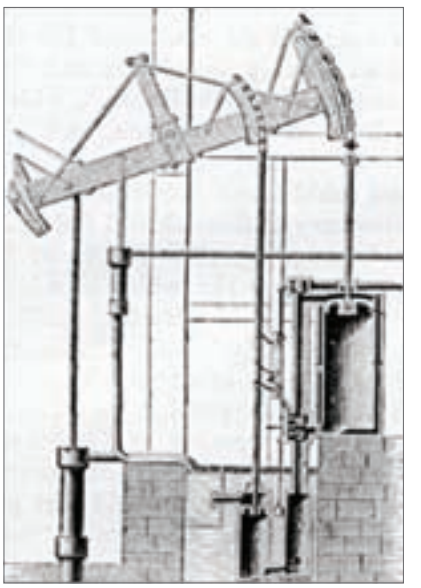
In other words, "kitonomic" innovation doesn't follow the money; the money follows the kits. Although government research funding and industrial investment undeniably matter, they shouldn't eclipse the importance of bottom-up mechanisms for human capital formation, such as kits.

Talented amateurs don't just build kits; kits help build talented amateurs. And healthy innovation cultures — and successful innovation economies — need the human capital that their talent embodies. Kits are integral, indispensable, and invaluable ingredients for new value creation.

ELECTRONICS, AIRPLANES, AND AUTOMOBILES

The great book on kits, their economic impact, and their techno-cultural appeal has yet to be written. But history strongly suggests that the more pervasive a technology, the likelier its origins are traceable to a homebrew/hobbyist ethos built around (and with) kits. As deliberately unfinished engines of innovation, kits inspire improvisational ingenuity, insight, and investment.

So while there may be no "Steve Jobs of Kits" yet, there is surely no Steve Jobs without kits. There's no Bill Gates or Akio Morita without kits either. Their market-transforming entrepreneurial leaps all emerged from kit-enabled cottage industries. The two Steves — Jobs and Wozniak — literally built Apple from kits. Gates and Paul Allen started Microsoft as a software systems



KITS AS CATALYSTS

James Watt's early steam engine kits, circa 1776, sparked the industrial revolution. In 1910, *Popular Mechanics* featured the first-ever free airplane plans (by Alberto Santos-Dumont). Henry Ford's early models became platforms for customization and upgrades.

"KITONOMIC" INNOVATION DOESN'T FOLLOW THE MONEY; THE MONEY FOLLOWS THE KITS.

FROM KITS TO COMMERCIAL GIANTS:
Sony's founders Akio Morita and Masaru Ibuka showing their early radio conversion kits (AM to shortwave).

AP Photo/Kyodo News

supplier for DIY computer kit builders. Morita and Masaru Ibuka launched Sony with kits to turn AM radios into shortwave receivers. From the prewar "cat's-whisker" playfulness of crystal radio kits to postwar floods of surplus electronics, kits became a medium, mechanism, and marketplace for next-generation invention.

Kit sensibilities, which value interchangeable parts and amateur tinkerability, enabled other revolutions as well. Aviation innovation, from the Wright Brothers' wind-tunnel experiments through Lindbergh's *Spirit of St. Louis,* reflects diligent amateur contributions as much as sophisticated engineering. Serious analysis of early aircraft production affirms that its earliest pioneers explored modifiable kits as much as finished planes (Alberto Santos-Dumont offered the first free airplane plans in the June 1910 *Popular Mechanics*).

Henry Ford's Detroit likewise evolved from homebrew subcultures of internal combustion and steam-powered hackers. Pre-industrialism, automobile DIYers relied on quasi-interchangeable parts and tools to craft their horseless carriages. Mass production was Ford's greatest innovation. But his breakthrough created more than a mass-market automobile; his Model T's and A's became kitonomic platforms for customization and technical upgrades. The general public — not just hobbyists — bought kits to make their Fords better, as documented by Kathleen Franz in her book *Tinkering: Consumers Reinvent the Early Automobile*.

Indirect "kitfluence" is comparably powerful. Adolescent model airplane competitions, for example, led Paul MacCready into aeronautical engineering and the creation of 1977's human-powered *Gossamer Condor*. The 1931 Grunau Baby glider construction kits proved essential to Nazi Germany's efforts to rebuild its aviation industry. And in the late 50s and 60s, MIT's Tech Model Railroad Club helped inspire DIY computing's "hacker" ethos, according to Steven Levy's *Hackers*. All of the most intriguing narratives of industrial innovation feature kits as either essential props or compelling plotlines.

KITS FOR GREEN TECH AND BIOTECH?

Looking back is easy. Looking around — and forward — to evaluate potential kitonomic influences is the greater challenge. To what extent do contemporary kits meaningfully anticipate future transformations? Does an absence or scarcity of kit-powered innovation communities stifle market development?

Government agencies and venture capitalists in America and Europe have been infatuated with "green tech" investments and "greenovation" markets. But neither breakout products nor breakthrough entrepreneurs have yet redefined the category. No Heathkits or Altairs of eco-sustainable kits have emerged to capture the hearts, minds, or imaginations of "human capital," and government subsidies and regulations appear to be the dominant market force. Might that help explain the sector's ongoing economic challenges?

Biotechnology invites the same argument. For years, many high-tech observers (myself included) have wondered if bio-hackers and "bathtub biotech" would drive bio-innovation. Might bundling low-cost recombinant DNA reagents, gene guns, and DIY PCR machines into kits make "re-engineering life" irresistible to hobbyists? If bio-hacking kits had attracted even 10% of the community that homebrew computing did, would pharma, veterinary

medicine, agriculture, bio-materials, or bio-informatics have become more vibrant?

These questions are no more hyperbolic or science fiction-y than extrapolating the iPad from the Apple I or even anticipating cheap mobile telephony from germanium crystal wireless kits. Quite the contrary: the mix of kits and talented amateurs encourages such speculation. Just as the presence of kit culture signals greater things to come in a field, its absence limits vitality and diversity.

Consider autonomous vehicles. Progress in the field crawled along for decades while the Pentagon was funding the problem through its usual contractor process. But then in 2004, the first DARPA Grand Challenge invited student groups and talented amateurs into the field. Through this and two successive competitions (the last in 2007), the winning vehicles leaped from being incapable of staying on an empty desert road to completing an urban course while obeying all traffic laws and avoiding other vehicles. And all for mere peanuts in defense budget terms.

Along these lines, don't Dean Kamen's FIRST Robotics competitions and *Wired* editor Chris Anderson's DIY Drones venture (see page 26), both of them DIY and kitonomic, suggest robotics futures more varied and "out of control" than anything envisioned inside the Pentagon?

MASS INTEROPERABILITY

The ultimate kits — meta kits — emerge when people develop their kit building blocks to work with each other. You see this with open source hardware like Arduino as well as the ongoing "appification" of software and digital services. Popular open standards and protocols subvert traditional business models, giving rise to global DIY R&D that enjoys far more brainpower than any company department, no many how many hot-shot engineers and designers it has hired. Perhaps this is why Microsoft — despite intense internal political battles — decided to turn Kinect into a DIY kit platform.

Consequently, the most exciting mass production consumer sectors increasingly defer to Web 2.0-ified economies of mass interoperability. As serial entrepreneur Joe Kraus brilliantly observed, "The 20th-century mass-production world was about dozens of markets of millions of people. The 21st century is all about millions of markets of dozens of people."

Yes, it is. Remarkable, isn't it, that kit mindsets and methodologies appear critical to both? The modularity, hackability, and improvisability that have made individual kits successful in the past become even more valuable when linked to higher-bandwidth swirls of wiki-ed and networked information. Higher-bandwidth and broader interactions between people facilitate higher-bandwidth and broader interoperability between kits. As tool chains and other innovation ecosystems evolve to be more kitlike, kits evolve into hardier innovation ecosystems.

And as (relatively) accessible

GAME CHANGERS

(clockwise from top): The Steves, Wozniak and Jobs, proudly show their Apple I kit; the first homebrew Apple computer; Microsoft's first software was for the Altair 8800b kit computer

➡ (Oppostie) MakerBot Industries is revolutionizing desktop 3D printing as the Arduino microcontroller is making physical computing accessible to all.

DB Apple/dpa/Corbis (Woz and Jobs); Ed Uthman (Apple 1)

MakerBot Industries (top)

technologies ensure the diffusion, dispersion, and development of technical knowledge and skills, the most talented of amateurs won't just "follow the instructions." They'll advance well beyond them, and invent possible futures. The technologies may be new, but the patterns of human behavior are not.

Academic thought leaders from Berkeley's Henry Chesbrough to MIT's Eric von Hippel celebrate "open innovation" as a profound paradigm shift in value creation. For Chesbrough, open innovation revitalizes stale innovation processes in established enterprise. For von Hippel, greater openness promotes a "democratization of innovation" worldwide.

THE MORE PERVASIVE A TECHNOLOGY, THE LIKELIER ITS ORIGINS ARE TRACEABLE TO A HOMEBREW/ HOBBYIST ETHOS.

TOWARD A STRATEGIC KIT INITIATIVE

Following this model, IP shifts from "intellectual property" to "innovation populism". What better instantiates open innovation than a kit, which entwines innovative components, innovative bundling, and, of course, innovative documentation and collaborative support?

But the transcendent issue is not whether open, proprietary, or "walled garden" kits represent the optimal format. It's that — no matter what regime is chosen — kitonomics appears to play an increasingly vital role.

If kits can influence and even drive sustainable innovation, then commercial and not-for-profit organizations alike should be asking what their SKIs (strategic kit initiatives) should look like.

Already we've begun to see these concerns materialize in NGOs and philanthropies in emerging markets (see "'Design for Hack' in Medicine," page 20). A growing number of development experts such as NYU's Bill Easterly believe customizable kits represent a better aid format than finished products. (Victor Papanek's classic *Design for the Real World* — more than E.F. Schumacher's *Small Is Beautiful* manifesto — best articulated this "appropriate technology" design emphasis.)

The smart money — are you listening, Gates Foundation? — would be on kits as mission-critical ingredients for dramatically stimulating quality-of-life and standard-of-living innovations in the world's poorer populations. After all, history indicates that kits are how emerging markets emerge.

And now, desktop fabrication and manufacturing literally bring another material dimension to what kits can be. The ability to integrate and interoperate digitally designed atoms and bits, to share physical objects remotely with download-and-print ease, can't help but transform design — and by extension, everything else.

What happens when the same hobbyist/homebrew subculture that spawned a Gates, a Jobs, and a Michael Dell grows around kit-built 3D printers in Brazil's favelas and India's public housing? How might microentrepreneurial design collaborations in Guangzhou yield high-impact kits inexpensive enough to seed talent and innovation throughout the world?

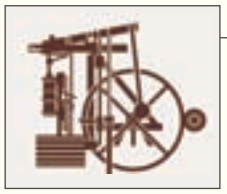
No meaningful answers to those questions yet exist. But we can be sure that the future of innovation is inextricably linked to the future of kits. ■

Michael Schrage is a research fellow at MIT's Sloan School Center for Digital Business and London's Imperial College Innovation and Entrepreneurship Group. He explores how organizations use models, prototypes, and experiments to manage innovation.

KIT TIMELINE

1775 · 1790 · 1805 · 1820 · 1835 · 1850 · 1865 · 1880 · 1895 · 1910 · 1925 · 1940 · 1955 · 1970 · 1985 · 2000 · 2015

1776
Boulton & Watt produce kits and plans for commercial steam engines.



1906-1940
Aladdin Company, Sears Roebuck, and others sell kit houses by mail.

1913-1939
Motorists use aftermarket kits to customize Ford Model A's and T's.

1910
Alberto Santos-Dumont offers first free airplane plans in *Popular Mechanics*.

1909-1967
A.C. Gilbert Co. develops science, chemistry, and magic kits, train sets, and Erector construction toys.

1930s
Schneider Grunau Baby glider kits help Nazi Germany rebuild its aviation program.

1926-1992
Heathkits are the leading line of kits in the U.S., from aircraft to TVs to computers.

1926–1931: Heath Parasol is the sole kit airplane licensed by FAA.

1947: First electronics kit: O1 Oscilloscope for $40.

1977: H8 computer kit, $379, leads to H89 in 1989.

1982: Hero-1 robot kit.

1992: Heath Co. closes Heathkit line.

1940-1989
Things of Science program delivers hands-on science kits to mailboxes across America.

1927
Charles Lindbergh's trans-Atlantic flight sparks craze for model airplane kits and competitions.

1945
Akio Morita and Masaru Ibuka launch Sony with kits to turn AM radios into shortwave receivers.

1975
Bill Gates and Paul Allen launch Microsoft with software for the Altair 8800 kit computer.

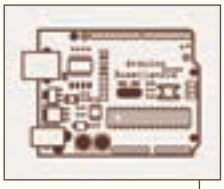
1975-1976
The Altair 8800 personal computer kit from MITS kicks off the PC revolution in DIY style. (MITS was sold to Pertec in 1976.)

1992
FIRST Robotics Competition debuts, challenging students to build unique robots from standardized kits.

2007
DIY Drones community and kits founded by *Wired* editor-in-chief Chris Anderson.

2008
RepRap 3D printer can produce copies of over half its own components.

1976
Steve Jobs and Steve Wozniak develop Apple I computer as a kit. Only 200 are made before they go on to develop Apple II.



2005
Arduino microcontroller debuts.

2009
MakerBot, RepRap, and other 3D printer kits become widely available.

RadioShack.

Make: technology on your time

2011
RadioShack begins selling MAKE-branded DIY kits.

2011
Heathkits back by popular demand.

Damien Scogin

COMIC BOOK KITS THAT SUCK

Robbing kids of their nickels and dimes.

BY KIRK DEMARAIS

A BOOK REVEALS THE DISAPPOINTING TRUTH BEHIND FANTASTIC-SOUNDING PRODUCTS SUCH AS X-RAY GLASSES, VOICE THROWERS, REMOTE CONTROL MONSTERS, AND SECRET SPY SCOPES.

For his book Mail Order Mysteries, *Kirk Demarais scoured eBay and collectors' websites to purchase novelties and kits that had been advertised in comic books in the 1960s and 70s.*

These kits appealed to the imaginations of kids who grew up in a popular culture full of flying saucers and monster movies, but they were nearly useless. Demarais writes, "For me the collection represents so many things: a series of hard-earned revelations, my remaining sense of wonder, and the coming-of-age discovery that even kids need to be shrewd as serpents lest we get bit by one." His picks for the worst:

SWINDLED BY MAIL: Just of few of the lame kits that cheated a generation.

Build Your Own Monster Plans $1
We imagined: Everything needed to assemble a monster, a weapon, and a friend.
They sent: What are quite possibly the doodles of a middle school student. The Abracadabra Magic Shop offered the "plans" for this illusion, which is intended to give the impression that a table full of parts springs to life after being assembled before an audience. The secret is a set of diagonal mirrors that conceal a person hidden within the chest.
Customer satisfaction: You'll feel empty inside.

9-Foot Hot Air Balloon $2
We imagined: A hot air balloon, definitely large enough to carry you and a friend.
They sent: Some string, some wire, and a whole lot of colored tissue paper. First, you follow the cryptic instructions on how to glue together the tissue to form a giant balloon. Next, you build a fire and funnel the hot air through a stovepipe (not supplied), though it's not likely that many kids ever made it to step two.
Customer satisfaction: Tempers will rise.

Build a Working Laser Pistol $2
We imagined: Schematics detailing construction of a sophisticated laser weapon, an essential device in every spy's arsenal — or in anyone's, really.
They sent: A booklet outlining how to project a harmless light beam from a toy gun using wire, glue, copper tubing, a mirror, flash cubes, batteries, and a plastic lasing rod. The task appears challenging for even a devout *Popular Mechanics* subscriber, let alone a kid. The laser's inability to disintegrate is a blow, considering the ad's boast that it's "used by the Argonne National Laboratory (Home of the Atomic Bomb)."
Customer satisfaction: Zaps you in the wallet.

Kirk Demarais

Kirk Demarais is an artist, designer, animator, filmmaker, and author of *Mail Order Mysteries* and *Life of the Party*, a visual history of the S.S. Adams Pranks and Magic Co. kirkdemarais.com

BUILD YOUR DREAM CAR

At Local Motors, enthusiasts create what big automakers won't.

BY JAY ROGERS

I BUILT MY FIRST CAR MODEL WHEN I WAS 8. IT WAS A DUESENBERG 1934 COUPE CHAUFFEUR. MAGNIFICENT. BODY PIECES THAT SNAPPED TOGETHER, METAL PANELS, CHROME INTERIOR DETAILS, GLASS WINDOWS THAT FOLDED DOWN, REAL FASTENERS, BURGUNDY INTERIOR FABRIC, RUBBER TIRES WITH WHITE-WALL SIDING, METAL SPOKES, CABLES, AND A MINIATURE MOTOR.

My older brothers bet I would never finish it, but I might as well have been glued to our playroom table because I didn't get up for three days that summer until the entire model was finished and gleaming. And I had just as much fun organizing my workspace, tools, glue, and paint as I did building the model. It was my first man-cave, the first little place in my life that my sister didn't want to mess with. The whole experience of car creation just seemed to be so essentially satisfying. I was hooked.

Thirty years later, I'm still at it. Only this time the cars are real, and I've learned to share the love with thousands of fans on the internet as together we design the cars that we're going to build together.

I run Local Motors in Chandler, Arizona, which is the first collaborative car design and engineering business wrapped up with the world's first micro-factory production facility. Here, customers are invited — no, required — to join us in the build of their car.

We recently began manufacturing our first car, the Rally Fighter. Designed by one of our 20,000-plus community members, Sangho Kim, it's a premium, authentic, off-road vehicle that's also on-road legal. Building a Rally Fighter at our micro-factory is the ultimate kit experience, priced at $74,900.

Courtesy of Local Motors

OPEN DESIGN

Here's how it works. Local-motors.com hosts the open collaboration space Local Forge, where people can post their ideas on anything automotive. Most of what's there is free exploration, but the discussions always come back to the essential question: "What would it look like if I were to make it real?" This is not a fantasy picture site, but a place where engineers, designers, and enthusiasts collaborate on stuff that

Sangho Kim's drawing of the Rally Fighter concept.

Kim working on the orthographic drawing.

"YOU CAN DREAM ANYTHING YOU WANT HERE, but to see it come alive, you must also justify your ideas to your peers and accept guidance from our engineering team."

the big automakers wouldn't dare to. You can dream anything you want here, but to see it come alive, you must also justify your ideas to your peers and accept guidance from our engineering team.

We also design for simple assembly. Our customers aren't trained auto workers, and we can't assume their level of expertise, so we steer designs to ensure the customer's capability and enjoyment as they build in our micro-factory. Each car must be buildable by two people in 12 days, from a clear set of instructions that the team develops on a wiki.

This open source ethos promotes understanding and sharing by all stakeholders, which eases manufacturing and service later. The result is that our build process accommodates all comers, from 13-year-old Iowa Boy Scouts to 85-year-old businessmen from Kazakhstan.

Our cars are literally open source. The build wiki is accessible and modifiable by anyone. Each build is broken down into day-by-day instruction sets, each with a text listing and photos of all the required parts and tools, and YouTube videos taking you through the entire build step. We build our cars here, but there is no part of a Local Motors car's assembly that someone can't study and replicate elsewhere.


Scale mockup.


Customers at work.


Body panels in construction.

THE RALLY FIGHTER

Sangho Kim was a young professional industrial designer who dreamed that Group B-inspired Dakar racing coupes like the Fiat Enduro, Porsche 959, and Lancia Stratos needed a younger brother available to the common man. He posted his concept drawings of a high-waisted, desert-running, P-51 fighter airplane-inspired, off-road car that could also work on the road. Kim's simple side views and gestural drawings from several angles described the feeling and stance of his Rally Fighter idea, which immediately caught fire in the Local Motors community.

In the next stage, the community discussed initial concepts of how to fit the necessary components inside the Rally Fighter. For this, we made orthographic packaging drawings, where the original concept is flattened into 2D planes from the side, top, and front and then the major systems (wheels, engine, transmission, driveshaft, axles, seats, steering, etc.) are placed in their proper orientation.

The result: the Rally Fighter would have a lightweight space frame, composite aerodynamic panels, 20-inch shock absorbers, and a mid-mounted engine with rear-wheel drive.

This exercise is effectively ground truth for the engineers focused on function, but any changes to the 2D orthographic views to accommodate gear can also alter the 3D appearance of the car in unexpected ways. To realign the space requirements with the original vision, we snap the orthographic lines back out into a 3D surface, add highlights, gravity effects, and texturing, then render the revised design. With the Rally Fighter, the community's gut reaction to the renderings was still powerful and positive. We had the makings of a potential car.

The next step was open development to get the Rally Fighter ready for micro-factory production. This is a grand effort, because with each car built, we have to train our "build force" (our customers) anew, so we've got to make the process as clear and supportive as possible.

THE FACTORY

At our facility, people equipped with only hand tools and desire, in a 10-by-15-foot concrete build bay, go from a box of parts to their finished machine over the course of two weeks. Our amazing architect worked round the clock on a minimalist plan that accommodated everything Local Motors needed in our 40,000-square-foot space, from our offices and "R&D cage" to the materials fabrication area, where chassis are welded and composites are formed.

We use scanners and 3D printers for fluid, rapid prototyping, and fabrication equipment like water jet cutters for rapid manufacturing. We limited the fixed machinery and put everything else on wheels so we can move it around. If you think a rolling crosscut saw is a bad idea, think again.

Our ten build bays are stacked together on the build floor so that customers can eyeball each other in a friendly game of "I can build to standard better than you can." Competition is an amazing motivator. If it works in Dearborn, it should work here.

The crown jewel of the build bay is your very own tool cart, which contains exactly what you need and nothing you don't. This cart disproves the common notion that you need every tool under the sun in order to build a car. Actually you only need a few; they just have to be the right few. Each bay also has a web-enabled screen to consult the all-important build instructions, which can be updated on the fly with new build-floor wisdom on the open wiki.

Finally, since we demand ten-hour days or more in this car-building boot camp, we include a kitchen and refreshment area managed by a local Arizona Culinary graduate who comes prepared to keep the troops well fed. A happy belly is a productive mind.

That's how we roll here, and if you breathe automotive and style, I invite you to visit local-motors.com and engage in real-time auto evolution: design, buy, build, and love the car of your dreams.

Jay Rogers is the president, CEO, and co-founder of Local Motors.

GILBERT'S GIRDERS

How 30 million Erector Sets became tools for children to teach themselves.

BY DALE DOUGHERTY

THE MUSEUM OF INTERESTING THINGS IS CRAMMED INTO EVERY INCH OF THE NINTH-FLOOR NEW YORK CITY APARTMENT OF DENNY DANIEL, THE SPRITE-LIKE CURATOR OF AN ECLECTIC COLLECTION OF INVENTIONS, TOYS, AND GADGETS.

Daniel had a magician-like patter for each item he showed me: the cylindrical Edison phonograph, the mutoscope, and the hidden camera inside a silver pocketwatch that was used by boxing reporters to take forbidden ringside photos. These inventions were the predecessors of devices and toys we use today, and Daniel wants the current generation to see that inventions don't come out of the blue.

On a table in his living room sat open a large red Erector Set, a construction toy I remember getting in the 1960s. Daniel's set was older and well worn. The manual said the Erector Set was "Developed at the Gilbert Hall of Science." I realized how little I knew about this toy from my childhood.

Located in midtown Manhattan, the Gilbert Hall of Science was a multi-story museum created in 1941 by the Erector Set's inventor, A.C. Gilbert, to showcase educational toys. Gilbert was born in Salem, Ore., and went East to get a Yale medical degree that he never used. He said he was interested in three things: "athletics, sleight-of-hand, and scientific experiments" and those interests would define him. He won the pole vault in the 1908 Olympics, having invented the box that catches the pole on the ground (before then, it had a spike at the end).

Gilbert's first business was making Mysto Magic kits. It was barely profitable, but while making train trips from New Haven, Conn., to New York, he was inspired by the steel-girder construction of bridges and skyscrapers to create a new kind of educational toy. He produced the first Erector Set in 1913, the year the classic *The Boy Mechanic* books debuted from *Popular Mechanics*. It was an immediate success, the right product at the right time.

Each Erector Set box was filled with steel girders, wheels, pulleys, and in larger sets, a battery-powered motor that brought the models to life. Different sets, numbered from 0 to 8, provided the parts for making specific models such as a train bridge or Ferris wheel. In the 1920s, the #8 Erector Set cost $70 and weighed a staggering 150 pounds; it included all the parts for building a 5-foot zeppelin.

Gilbert saw the Erector Set as an ideal toy for the ideal boy, which he defined as competitive, clever, and curious, like himself. His biographer Bruce Watson argues that Gilbert didn't just invent educational toys, he transformed the popular image of the American boy from problem child to problem solver, from delinquent to constructive contributor.

Perhaps the first to create advertising that spoke

Erecting the Future: Marc Fornes and TheVeryMany

In an old bank building in Brooklyn, irregular strips of brushed aluminum about a yard long are spread on the floor. Two people bend them to fit a tubular structure and pop-rivet them in place. Each piece is numbered; the builders consult a computer to learn how they fit together. It looks like a giant coral made from metal.

This is the sculpture *Fibulae* by architect/computer scientist Marc Fornes and his team TheVeryMany (theverymany.com). He designed it using Rhino3D, and wrote scripts to create 2D patterns for the strips, so each one could be custom-cut on a CNC machine. Perhaps, instead of starting with standardized components, the Erector Set of the future will begin with design tools for creating the parts.

A 1950 Erector Set: "The World's Greatest Toy."

With Erector toys, A.C. Gilbert made kids a part of America's can-do society.

Francois Lauginie (TheVeryMany)

directly to young people, Gilbert's ads opened with his characteristic "Hello Boys." His slogans for the Erector Set included "Young Boy's Paradise," "1000 Toys in 1," and "The World's Greatest Toy."

Gilbert believed children will educate themselves if you give them the right tools — an idea shared more recently by technologists like Seymour Papert of MIT. In an age when most learning was rote memorization, Gilbert saw the importance of creative play and exploration. He made learning fun.

From 1913 to 1966, 30 million Erector Sets were sold. The toy's popularity spanned the technological era from the Model T and electrification to the age of aerospace, and it evolved to keep pace with these developments. It reflected the can-do spirit of the American Century, a society that was rapidly gaining new abilities to solve problems and do ambitious projects thanks to science and technology. The Erector Set was an invitation for any boy to participate in that future.

Erector's decline followed Gilbert's death in 1961, and the A.C. Gilbert company went bankrupt in 1967. The brand was bought by Meccano, an English company whose comparable construction kits grew in parallel to Erector. Lego became the educational construction toy for the video game generation, and today, Gilbert's image of the American boy seems almost corny, like a Normal Rockwell painting. Still, we recognize him in ourselves and in our kids.

What will be the Erector Set of the 21st century? What construction systems will reflect the methods and personalities of a more diverse group of builders that includes girls and a more global perspective?

Maybe we're already seeing key components in Arduino, MakerBot, and Kinect, all of which represent new ideas about how to build things and interact with them. Perhaps a new generation will build custom construction sets, as does architect Marc Fornes (see above), designing and cutting pieces to order. I see Maker Faire and MAKE as successors to the Gilbert Hall of Science, inviting kids to build a future for themselves.

Dale Dougherty is founder and publisher of MAKE.

"DESIGN FOR HACK" IN MEDICINE

MacGyver nurses and Legos are helping us make MEDIKits for better health care.

BY JOSE GOMEZ-MARQUEZ

CLINICS IN THE DEVELOPING WORLD NEED DEVICES DESIGNED LIKE LAND ROVERS: RUGGED, ACCESSIBLE, AND EASILY REPAIRABLE IN THE FIELD.

Medical aid is a good story. We've all seen articles about well-meaning groups donating X-ray machines and incubators to needy clinics in the developing world. What we don't see are those same devices when they fail as little as six months later — or even dead on arrival — because they weren't designed to operate in these environments.

About 90% of medical technology that reaches poor countries is hand-me-down equipment designed for first-world facilities. Expecting it to keep working is like expecting a used Rolls-Royce to survive the Paris-Dakar Rally. And after it malfunctions, it's usually junked.

In response, some designers have felt that we need to send over cheaper versions of the high-end equipment, the equivalent of economy cars. But what these clinics really need are Land Rovers — devices designed to be rugged, accessible, and easily repairable in the field.

Fortunately, increasing numbers of professionals in the medical equipment industry are becoming interested in applying this different design philosophy to devices aimed at developing countries. My lab at MIT, Innovations in International Health (IIH), is taking this approach even further, by getting everyday makers around the world to design and maintain their own medical technology.

Using the Drug Delivery MEDIKit in Nicaragua.

Jose Gomez-Marquez

MacGyver Health Care

In developed countries, we rarely think of modifying medical devices. Isn't that the job of a professional? But in most of the developing world, doctors, nurses, and health care workers tinker with failing medical technology every day to fix it or make it work better.

These health hackers are often secretive about their solutions, however. The first time we saw a medical hack, it took us two hours to convince the nurse, Daniela Urbina, to show us how she had fixed the cracked diaphragm of her stethoscope. A young woman from central Nicaragua, she had experimented with various plastics to replace it, and settled on leftover overhead transparency material cut into a circle and taped inside. It wasn't pretty, but it worked. We quickly dubbed her a MacGyver nurse.

It's tragic that Daniela wasn't proud of her innovation. But in the IIH lab at MIT, we're developing MEDIKits (Medical Education Design and Invention Kits), construction sets designed to encourage invention among doctors and nurses in the field.

MEDIKits: Designed for Hacking

Our MEDIKits currently come in five flavors: Drug Delivery, Lateral-Flow Diagnostics, Lab-on-Chip, Vital Signs, and Agricultural Prosthetics. The kits started as boxes of parts assembled to familiarize MIT stu-

The PuzzleDx kit design for Lateral-Flow Diagnostics.

An Agricultural Prosthetics kit in use.

The PuzzleDx kit's diagnostic puzzle pieces.

The Drug Delivery kit.

dents with medical devices, and evolved to include linear components that you can assemble like Lego bricks into a final device. Through the process, we developed a modular design language to help users see the underlying logic to connecting the parts, and added physical stops to keep some components within safe ranges of operation.

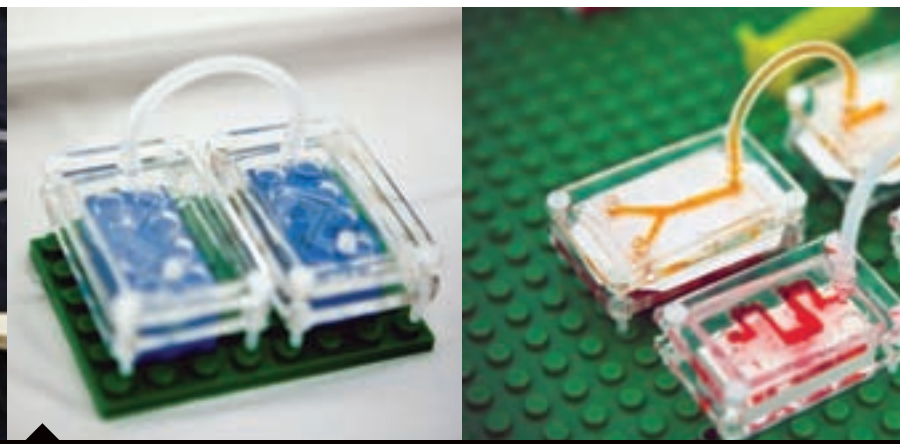
Nothing beats field experimentation to understand whether a kit works. In our case, we would run across the river to the Boston hospitals and share the kits with colleagues, and then fly to Nicaragua, open the box, and see what people would do with them. Each kit provided us with insights into the design of an invention space — which ultimately is what you want.

The Drug Delivery Kit was our first experiment. It's divided into core devices: syringes, nebulizers, inhalers, transdermal patches, pills, and several other items you might find at your local pharmacy. Then we added modifier elements: color coding, shape coding, couplings, extenders, springs, plungers, compressors, tilt sensors, buzzers, timers, bicycle pumps, and template cutters. These items let users couple and change the functionality of the core devices within specific degrees of freedom. Finally, we added a healthy amount of consumable general-purpose materials: zip ties, velcro, adhesives, paper and plastic sheeting, tubing, needles, and respiratory masks. The last thing you want is for your users to start compromising the modifier's safety limits because they ran out of tape.

We designed the limits of our early kits carefully, but when users began to snap on, extend, and test their creations, something emerged that we did not anticipate: they hacked our kits. It starts with someone asking permission to simply cut a piece of tubing and bypass our carefully designed coupling. Or taking a part they find in one kit and using it for another, for example, adding diagnostic tubing into a mechanism to disable syringes for safety. As users take ownership of a kit, you as the kit designer become less involved in training people how to use it.

So for the kit to be successful, you have to Design for Hack. And while it's impossible to predict every type of device a kit can produce, you can start with

The modular Lab-on-Chip kit.



Lab-on-Chip microfluidics modules on Lego bases.

a core set, add degrees of freedom to that core, and then anticipate and design areas in which those degrees will be hacked.

Our Agricultural Prosthetic MEDIKit is a good example. Some great organizations such as Jaipur Foot provide affordable prosthetics, but if you're a farmer in the developing world today, and you have the misfortune of losing an arm, you'll probably be given a plastic hand that's aimed at looking good but not very functional (and there's no way you'll be able to afford a sensor-laden robot hand).

The Agricultural Prosthetic MEDIKit uses a universal gripper made from PVC, bicycle inner tubes, and a soda bottle to attach most farm tools onto the arm or forearm of an amputee farmer. Each part of the kit follows the same three principles: core device, modifier device, and consumables.

Since the price of all three is so small, users have no problem in modifying the core components to make them work better. One person did away with the MIT-designed inner tube, and simply cut a notch in the PVC joints to let the excess tubing out of the way, creating a sling to carry the whole thing. And instead of using the shorter parts provided, they quickly attached long pieces such as broomsticks and telescoping fruit pickers.

Languages of Design

If you've ever tried to explain over the phone something like how to replace a headlamp in a foreign car, you know how frustrating it is to lack a language of design. "The little plastic knob with screws ... yes I understand there are four knobs, try the first one...."

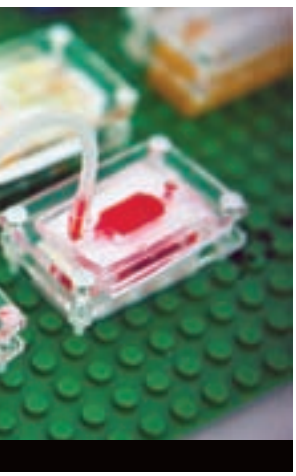
We realized that many of the components we included in the kit might be foreign to their users: English-language labels, injection-molded parts, tiny inhaler mechanisms, reagent combinations. To avoid confusion, we created a Language of Design, a way of color-coding each component in a logical manner so that people can identify its function immediately, and share their designs simply by describing the sequence of coded parts, and not the often-intricate mechanisms themselves.

Our PuzzleDx kit does that in a fun way for Lateral Flow Diagnostics, the class of absorbent paper-based diagnostics that includes pregnancy tests. These tests contain three components: a sample, a reagent pad, and a paper pad that collects excess fluid. We knew we couldn't give users a crash course in chemical diagnostics so they could pipette their own reagent combinations on blank pieces of reagent paper. But we could get them to put together puzzle pieces in a sequence that would make sense.

So we color-coded different puzzle pieces according to the reagent paper contained within and cut slots in the pieces to connect the sample collection and reagent papers when the puzzle pieces were joined. By sharing the types of color combinations and the order in which they're connected (which can be as easy as snapping a picture on a cellphone), users can easily re-create experiments without having to publish a formal protocol.

By using Languages of Design, you encourage communication across your user communities, facilitate understanding, crowdsource patterns of inventive behavior, and allow recognition of those patterns. If the Flickr MEDIKit group is getting filled with pictures of prototype combinations with the Yellow, Green, and Blue reagent blocks, it may mean that manufacturing engineers should really start looking at mass-producing glucose, ketones, and human chorionic gonadotropin combinations.

When was the last time your pregnancy test did that?



Toys: Local and Globally Available Materials

A toy helicopter has a rack and pinion mechanism. A toy Ferris wheel turned on its side is an excellent centrifuge. A scrapbooking vinyl cutter is a pretty good CNC machine for making microfluidic channels. Makers have made repurposing materials a competitive sport, and health hacks are no exception. While many of the parts in our kits come prepackaged, we've also seen our users find and invent locally available replacements and accessories from toys.

Now, when we go into a toy store, we see a mechanism paradise. Toys make up an amazing supply chain of cheap plastic and electronic mechanisms with fairly good tolerances for most medical applications. Early on, our team was intrigued by what we call the glucometer and the Gameboy paradox. Both of these devices have equally complex electronics and comparable retail price points, but dramatically unequal distribution. I can find a handheld game console almost anywhere around the globe, even in very small towns in the developing world, but in Estelí, Nicaragua, 16 different clinics had to share a single glucometer.

Instead of trying to change the global supply chain for medical devices, we have learned to embrace the existing one for toys. Go to your toy store, and you'll see the same $2 toy gun that a Nicaraguan nurse spotted and hacked into an alarm for an IV fluid bag, after harvesting the electronics and adding a simple trip mechanism. Lego blocks have very precise tolerances for creating modular microfluidic components. On the way out, toward the bicycle section, pick up a bike foot pump so you can power your nebulizer for $5 instead of paying $75 for the electric compressor sold in medical supply catalogs. Bonus feature: when there's an asthma emergency in the middle of nowhere, you won't need electricity to save the patient.

Trickle-Up Innovation

Places like Nicaragua have some of the poorest areas on the continent. But what about Nebraska? What about healthcare at home? For years, health technology has been shielded from tinkering and DIY invention because of the perceived barriers to entry: you're not a doctor, you're not a biomedical engineer, you require professional supervision. Health equipment has to be safe and rigorously tested, first and foremost.

All true, but along the way, that message got blurred with professional requirements that are not answering our need to make healthcare affordable. Try to buy a simple pillbox that lets you know when grandma took her pills: some are several hundred dollars. Makers build bird feeders that have the same functionality for a fraction of the cost. A surgical sterilizer costs $1,000–$8,000. But Anna Young got the same functionality by hacking a $30 pressure cooker and adding some DIY solar technology. A $30,000 incubator? Dr. Kris Olson made an incubator out of car parts for about $1,000.

Medical invention kits have the potential to lower many of these barriers and put health hacking back into the hands of users and of patients — the people who have the most to gain from affordable and elegant innovations. As the developing world gets a head start on DIY medical technologies, we'll see many of those user-generated inventions make their way back to richer countries.

IF YOU'RE A MAKER THINKING ABOUT HACKING HEALTH, or someone in healthcare thinking about creating something tangible, I invite you to try it.

An Invitation

As skyrocketing healthcare costs converge with the democratization of making, many more people will hack health. Whether it's putting RFID stickers on pill bottles to help patients take their pills on time, or hacking bike pumps and scrapbook cutters, health is filled with fantastic challenges. You can make a difference whether or not you work in healthcare.

Medical devices are very tangible things. One of the reasons I got into the field is because I knew I could create things that you can hold in your hand, give to someone else, and make a positive difference. If you're a maker thinking about hacking health, or someone in healthcare thinking about creating something tangible, I invite you to try it. Start with a kit or a toy, and you'll find a community that is eager to embrace your creations. We might even hack them, and we might even heal someone.

Jose Gomez-Marquez hacks health for the developing world in his lab at Innovations in International Health at MIT (iih.mit.edu). He is the founder of LDTC+Labs (ldtclabs.com) and can often be found in toy stores around the world or at jfgm@mit.edu.

THE SOUL OF AN OLD HEATHKIT

A generation grows up building DIY kits.

BY DALE DOUGHERTY

HOWARD NURSE BUILT HUNDREDS OF HEATHKITS. AS A KID, HE LOVED TO GO TO SLEEP READING THE CATALOG – A WINDOW INTO THE WORLD OF ELECTRONICS AND A WISH LIST OF THINGS HE WANTED TO BUILD.

"You have to understand the whole experience of a Heathkit," Nurse said. "It began with the catalog, which became part of my dreams and fantasies." Once he had placed an order, he would count the days until his Heathkit box arrived at his home in New Jersey. "Finally you'd get the package in the post box, after all this anticipation."

Electronics weren't readily accessible in the 1950s. The only place Nurse could see electronic components was at a local TV repair shop, which he hung around. The Heathkit catalog opened a door to the new worlds of hi-fi components, electrical test equipment, ham radios, and television sets. His first build was a ham transmitter, the DX-40.

Nurse recalls the joy of opening up the Heathkit box. "First, you'd see the Heathkit manual, which was the heart of the kit." Then he'd find the capacitors and resistors in brown envelopes. A transformer came wrapped in spongy paper, a predecessor of bubble wrap. "Before you did anything, you had to go through the errata that came with the kit." Then he'd inventory the parts and sort them in a muffin tin.

"After all this waiting and preparation, you'd begin to assemble the parts," he said. "You started by attaching a few components, and then you got to solder, which was really fun." When you finished and tried it out, often it didn't work. This, too, was part of the process of understanding electronics and learning to fix problems.

Nurse eventually got an insider's view of Heathkit.

Howard Nurse's first Heathkit was the DX-40 ham radio transmitter (far left).

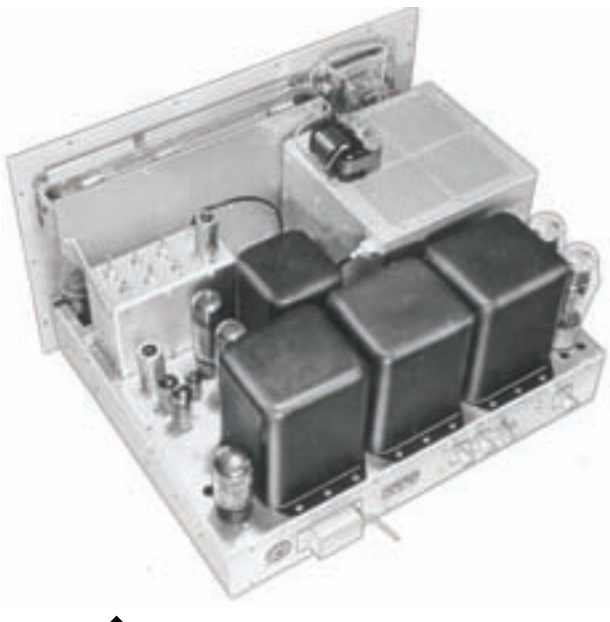
Courtesy of Terry A. Perdue

In 1964, his father, David W. Nurse, joined the company as vice president, just as Howard was going off to college. He was promoted to president in 1966 and remained in that position until he retired in 1980.

The Heathkit Company got its start in the 1920s as the Heath Aeroplane Company. Founder Eddie Heath developed do-it-yourself aircraft kits; his most famous was the Heath Parasol, with an overhead wing. Unfortunately, he was killed in 1931 in an airplane accident.

An engineer named Howard Anthony bought the company from Heath's widow in 1935. After World War II, Anthony bought a large stock of surplus wartime electronic parts, among them 5" CRTs (the legend is that he ordered a case but a carload arrived). He designed an oscilloscope kit for $39.50 and began to sell it through mail order. It took ten years to go through the original CRT shipment. According to an excerpt from the Heathkit Catalog found on heathkit-museum.com, Anthony's success was based on "the premise that anyone, regardless of technical knowledge or skills, could assemble a kit

"You have to understand the whole experience of a Heathkit," he said. "It began with the catalog, which became part of my dreams and fantasies."



The TX-1 "Scratchy Apache" transmitter is still in use.

The H8 Digital Computer, a huge hit, rocked 4K of RAM in 1977.

himself, and save up to 50% over comparable factory built models. All that would be required were a few simple hand tools and some spare time."

In 1951, Anthony also died in an airplane crash. The company changed ownership several times, but continued to produce innovative kits, including a color TV set in 1964. Heathkit did $100 million in annual sales in the 70s on a wide variety of kits, including furniture and satellite TV receivers.

"The Heathkit philosophy," said Nurse, "was that they didn't invent new products; they looked for products that were already successful in the market," then turned them into kits for the DIY market.

Nurse believes he may have had a role in persuading Heathkit to undertake its first digital computer. In 1975, the cover of *Popular Electronics* featured the MITS Altair 8800, which originally sold as a kit that required the user to solder and assemble the components. Noticing that it was selling well, he told his father that there should be a Heathkit computer. In 1977, Heathkit launched the H8 Digital Computer, and it proved to be extremely successful. Based on the Intel 8080, the H8 came with 4K of RAM and a cassette-tape-based operating system. It had a keypad on the front and a nine-digit display. Nurse wrote a radio Teletype software program for the H8 and started his own business selling it.

In the 80s, interest in DIY electronics declined, and the Heathkit Company stopped making kits. The old Heathkits live on as memorabilia exchanged on eBay, and in enthusiast websites and Yahoo! groups.

"I'll bet that every engineer in this country over the age of 50 grew up building Heathkits," said Nurse. "Heathkits were special. The best way I can explain it is," and he paused. "A Heathkit had a soul."

UPDATE: HEATHKITS ARE BACK!

In September 2011 Heathkit resumed selling kits for the DIYer. Look for new home electronics kits — Garage Parking Assistant, Wireless Swimming Pool Monitor — and soon, tube-driven audiophile gear and amateur radio kits. heathkit.com

Dale Dougherty (dale@oreilly.com) is founder and publisher of MAKE.

HARDWARE THE HARD WAY

How not to make a kit: lessons from Chris Anderson of DIY Drones.

INTERVIEW BY KEITH HAMMOND

ASIDE FROM HELMING *WIRED* MAGAZINE, CHRIS ANDERSON IS WELL KNOWN TO MAKERS AS CO-FOUNDER OF THE DIY DRONES COMMUNITY OF UNMANNED AERIAL VEHICLE ENTHUSIASTS.

Collaborating at diydrones.com, in 2008 the group revolutionized amateur robotics by creating a drone autopilot based on the cheap, open source Arduino microcontroller (*see MAKE Volume 19*). The ArduPilot turns any R/C plane or copter into a fully autonomous UAV.

Anderson sees a future where robotic aviation is ubiquitous. He created the first DIY kits using the ArduPilot, then founded 3D Robotics, a company making parts, kits, and ready-to-fly UAVs. We asked him what he's learned.

You're a DIY robot enthusiast who became a hardware manufacturer and kit maker. Any lessons to share with aspiring kit makers?

Well, I created exactly one kit myself: the robot blimp, on the dining room table, with my children doing the packing. That was a horrible mistake — do not put a 5-year-old in charge of packing.

The biggest lesson is that I should not be creating kits. The DIY Drones community is developing amazing technologies like the ArduPilot. We've created a business with several large factories creating kits, and they do it much better than me and my kids.

I'm chair of 3D Robotics, which makes the ArduCopter kit brain, and we work with others who make their own kits. We've got more than 120 different SKUs. It's a multimillion-dollar operation now; some are kits, some are just boards.

What tipped your decision to sell UAV kits, rather than just share designs?

Three or four years ago I built the Blimpduino. I had the idea that you could have an autonomous blimp that would fly around in schools, and it would be great for teaching kids about robotics.

So we designed the board, and we put the Eagle files up, and said here's a link to SparkFun's BatchPCB, here's the parts list to buy from Mouser and Digi-Key, and here are the instructions for putting it all together.

That's when we realized it was too hard — people just weren't going to do it. We had to build the board for people.

I made about three boards and said, "I'm never doing that again." So we got a contract manufacturer, and found out that you really have to order at scale to get pricing. We got the money together to buy 500 boards — you have to make a leap of faith, take some capital risk to get the volume. It was a little scary.

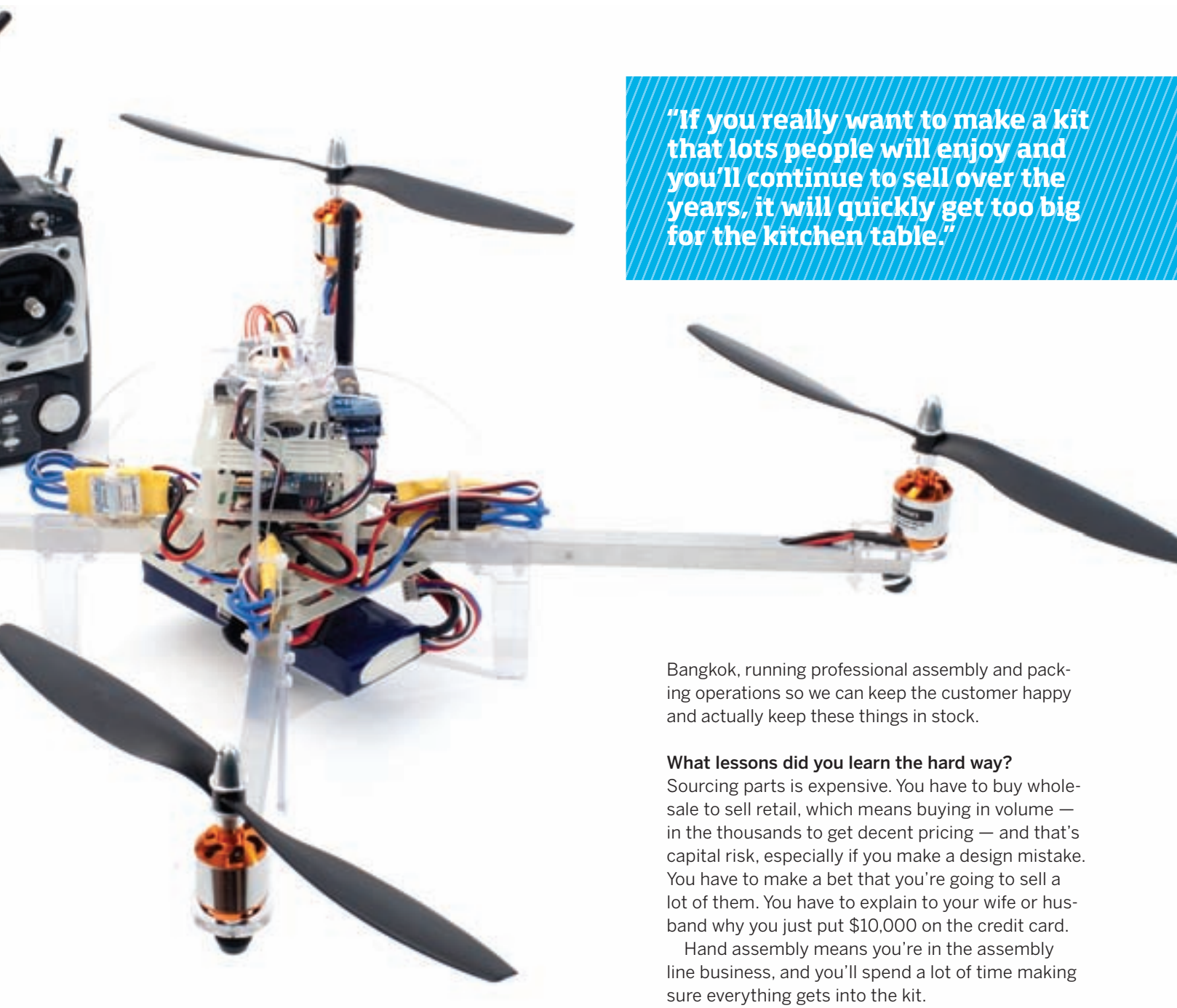
Then we realized that sourcing the other parts is also hard. Regular folks have no experience in it. I spent a ridiculous amount of time learning the economics of mylar balloons. The learning curve is steep and expensive.

Kitting it was the only way to really get it into people's hands.

What did it take to make that first kit?

The blimp envelope, the laser-cut parts, the motors — it was the same process sourcing these. We had

www.buildyourowndrone.co.uk



"If you really want to make a kit that lots people will enjoy and you'll continue to sell over the years, it will quickly get too big for the kitchen table."

to work with Chinese manufacturers through Alibaba to get the motors. It took months to get all the boxes of components. This meant volume ordering from a dozen different suppliers, getting samples, building test boards — all before we could sell the first kit.

Eventually we got all the parts, got the boards built and tested, the firmware loaded, labels printed, and at that point I bribed the children for $1 an hour. We labeled all the parts and set up an assembly line on the dining room table. I was doing quality control, but in the end, despite all our efforts, about half the kits were missing a part. I spent months sending out extra Lego parts or motors to people. I think it's cute that a 5-year-old forgot to put in a part, but the customer might not be as charmed.

Now we have factories in San Diego, Tijuana, and Bangkok, running professional assembly and packing operations so we can keep the customer happy and actually keep these things in stock.

What lessons did you learn the hard way?
Sourcing parts is expensive. You have to buy wholesale to sell retail, which means buying in volume — in the thousands to get decent pricing — and that's capital risk, especially if you make a design mistake. You have to make a bet that you're going to sell a lot of them. You have to explain to your wife or husband why you just put $10,000 on the credit card.

Hand assembly means you're in the assembly line business, and you'll spend a lot of time making sure everything gets into the kit.

Often, worse than failing is succeeding. This is not a one-time exercise — if you create 1,000 kits and succeed, you've got to do it again! The third time, I had to pay the kids way more than $1 an hour. As a kit maker you may discover that the worst thing that can happen is that these things become popular: "Oh no, we can't keep them in stock!"

Don't forget to sell it for a profit.

What would you do differently?
I wouldn't do it myself next time; that's why we started the company. Lines of credit, efficient sourcing, anti-static procedures, dealing with holidays in China ...

If you really want to make a kit that lots of people will enjoy and you'll continue to sell over the years, it will quickly get too big for the kitchen table. Find

ArduCopter Hexa with camera mount, by jDrones and Chris Anderson. An assembled DIY Drone with parts totaling about $300.

Amateur assembly: Anderson's kids. Pro assembly: Arturo in the San Diego factory. An ArduPilot Mega board is born.

a commercial partner that really cares about quality control. It's a real business involving paid professionals doing quality assurance, answering customer support calls, ensuring that this thing is good and stays in stock. As enticing as it is to create a kit, it quickly becomes unfun if it's successful.

Also, the tech support on kits is a nightmare. It imposes a huge aftermarket burden: you've got to help people fix it, or take back kits.

In this issue, MIT's Michael Schrage says that kit makers like DIY Drones suggest a robotics future "more varied and 'out of control' than anything envisioned inside the Pentagon."

Do you see amateur UAVs getting out of control? (I'm thinking of the so-called drone terrorist arrested by the FBI.)

First off, there's no evidence that that guy had GPS or anything other than an R/C plane.

We don't control the use of this technology; our kits are not locked down. If you buy a commercial autopilot you can lock it from going to certain places, but that's antithetical to our vision of openness. We have really strong guidelines to ban and report any activity using UAVs in dangerous ways or as weapons.

Openness means most people will use it for good, and some will use it for bad, but that's true of any tool: computers, cellphones, even hammers. There are those who want to ban technology and ban the maker instinct.

So what's the future of UAVs in the hands of amateurs?

We started with kits, but we're very quickly moving toward Plug and Play — there's two orders of magnitude difference in the sizes of those markets. If you have to put two parts together, you've eliminated half your market — and if you have to solder something, you've eliminated 99.9 percent of your potential market!

Chris Anderson is a father of five, editor-in-chief of *Wired* magazine, chairman of 3D Robotics, founder of GeekDad, and author of the tech-future books *The Long Tail*, *Free*, and an upcoming book on the new industrial revolution.

Jani Harvinen (hex); John Snyder (plane); courtesy of Chris Anderson

A KIT MAKER'S MANIFESTO

Rules for Creating an Open Source Community, by the team at Arduino

1. Don't make something you don't use yourself.
2. Know who you are making it for.
3. Know what you want out of it.
4. Make projects, not platforms.
5. Respect the intelligence of the beginner.
6. Experts are not the best advisors when you want to make tools for beginners.
7. If nobody complains, you're doing something wrong.
8. Everything is a spring (i.e., in mechanical systems, all parts will deform under load).
9. Including people is hard (but necessary).
10. Good hardware, good software, good explanations, and generous users make a great project.
11. If you're not prepared to have someone adapt, improve, clone, or trash your work, don't share it.
12. Open source software doesn't necessarily translate into a business model. Open source hardware must.
13. Expect resistance … and conspiracy theories.
14. Don't let the fact that you don't know what you're doing stop you.

MAKE Ultimate Kit Guide Rating System

BY KEITH HAMMOND AND PAUL SPINRAD

WHAT WE LIKE IN A KIT

What's the ideal kit? For starters, it should be well designed, made, and documented. You can read our criteria for rating those qualities below. Beyond this, it depends on you – your interests and abilities, and where you want to take them.

OUR FAVORITE KITS ARE ONES THAT:

- Save money when compared to buying a finished product, and make something of equal or higher quality.
- Are easy to fix when they break, because you know where every nut, bolt, and component is and how they fit together.
- Are fun to build, and teach you during the building process.
- Elicit admiration when you tell people you built it yourself.
- (Most importantly) push the limits of what you thought you were capable of, giving you a great feeling of accomplishment.

ABOUT THE RATINGS

To give our reviews a common basis for comparison, we asked reviewers to subjectively rate each kit on a 1–5 scale for five qualities. Kits without a reviewer byline were previously tested and approved to sell in the Maker Shed store (look for the Shed logo).

Complexity (1=Easy, 5=Difficult)
Is the kit easy, moderate, or challenging to build for its most likely target audience? Kits clearly aimed at children would, for example, be rated differently from microcontroller kits.

Component Quality
(5=Highest quality)
How nice are the components in terms of materials, design, fit, and other qualities? Well-made circuit boards, computer-cut plastic and metal parts, and other precision components add to the experience.

Documentation Quality
(5=Highest quality)
How clear, complete, and polished is the documentation? Some of the best instructions, like from Makey award-winner Lego, don't use words, so they can be understood by anyone.

Community (5=Most community)
How much of a community is there around the kit? Are there builder groups, online forums, circles, and meetups? Is the kit used in classrooms or after-school programs? Do the kit makers or builders have a presence at events like Maker Faire?

Completeness (5=Most complete)
How complete is the kit? Plans only? That rates a 1. Parts bundles and kits rate 2–5, depending on whether it's just key components, almost everything, or absolutely everything you need, including any unusual tools.

NEW: MAKE: Kit Reviews – Your Trusted Source Online

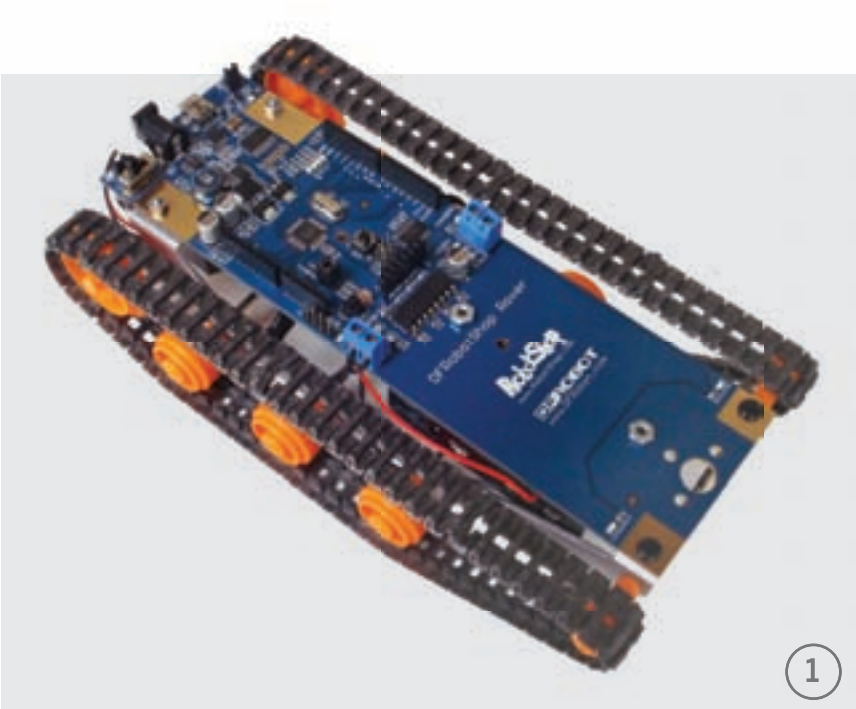
Welcome to the world's best source for the inside scoop on kits. We've created a curated collection of the coolest kits in every category known to man — hundreds of kits, hand-picked and reviewed by makers like you, who've built, tested, and rated them all. We break the flimsy parts, curse the bad instructions, and crush crappy kits to bring you only the best.

Want to find a quality kit?
Visit MAKE: Kit Reviews at
kits.makezine.com

ROBOTICS

BY GORDON MCCOMB,
FATHER OF HOBBY ROBOTICS

There's almost no limit to what a well-designed robot can do.



1

1. DFRobotShop Rover

DFRobot and RobotShop.com $90
robotshop.com

Complexity	2
Components	4
Documentation	4
Community	5
Completeness	4

Here's an easy-to-build robot base that combines a custom Arduino development board with inexpensive motors and tank-style tracks. It even comes with its own lithium polymer power pack and self-charging circuit, so you don't need to add batteries.

To construct the DFRobotShop Rover you have to first assemble the twin motor gearbox and rubber treads – both are pre-packaged products from Tamiya. Then it's just a handful of screws and plastic rivets. Total build time is about an hour. Tip from me: use only your fingers when assembling the rubber treads; sharp tools can tear the rubber.

The Rover's electronics are essentially an Arduino with a motor driver circuit. I recommend adding a bare-bones Arduino prototyping shield, and with some velcro tape, the shield will also work as a slip-proof shelf for the LiPoly battery.

To make the robot truly autonomous you'll want to add sensors, like a Ping ultrasonic distance ranger. Pre-drilled holes at the front of the Rover accept Lynxmotion Servo Erector Set parts, and RobotShop promises that on the next version (available Fall 2011), they'll add a prototyping area on the front end.

A final word of advice: consider swapping out the 3V motors included with the Tamiya gearbox kit for more efficient 6V versions (RobotShop #RB-Sbo-50); they're under $2 each.

2. Mr. General Mobile Platform

Arexx / Dagu $67
robotshop.com

Complexity	3
Components	4
Documentation	4
Community	3
Completeness	3

Mr. General is a solderless breadboard on wheels – one of my favorite ways to play with robotics. Mr. General puts it all on a sturdy frame, throws in a nifty servo-operated object detector, and even 140 colored wires. You supply the microcontroller; I recommend a small all-in-one board, like the BASIC Stamp, Boarduino, or Arduino Mini Pro.

The circuit board provides power to the four servomotors included in the kit: two for the wheels, and two smaller motors for a pan/tilt turret, where you mount the "compound eye" proximity sensor.

This kit requires extensive soldering, and a build time of 4-6 hours. Using 1.2V rechargeable batteries, you can power a 5V microcontroller without a voltage regulator. For controllers that need 7V, use a boost circuit like the Pololu Adjustable Boost Regulator (pololu.com #799), but power the motors from the batteries.

3. Wind Up Workshop Robots

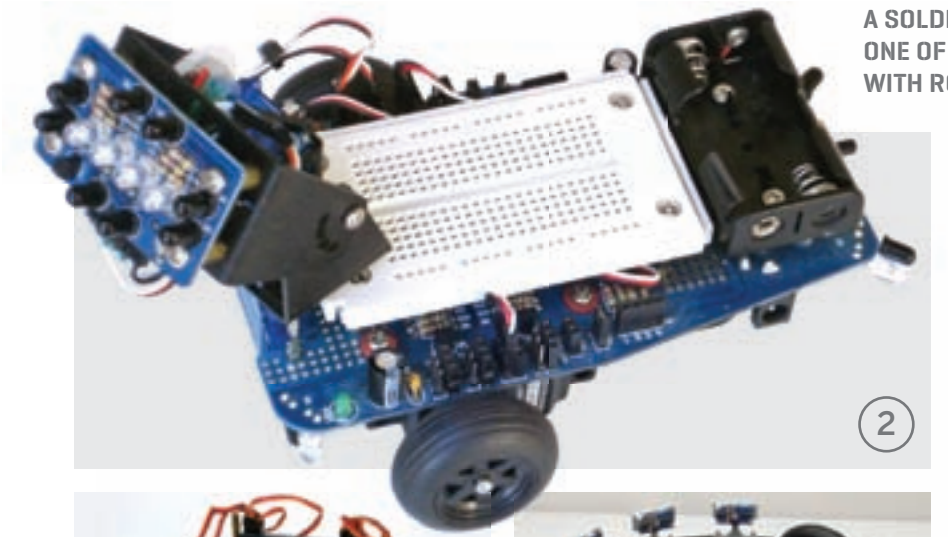
Faber-Castell $15
creativityforkids.com

Complexity	1
Components	4
Documentation	3
Community	2
Completeness	5

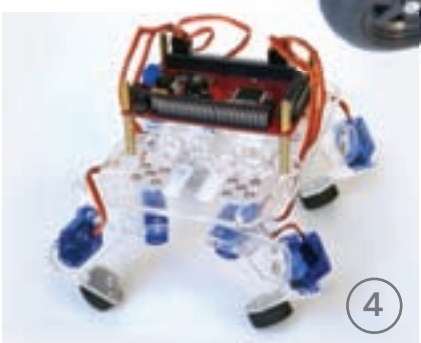
Who would have thought a company that makes pencils and pens could come up with such a cool robotics kit for all ages! Inside the box are five windup mechanisms, plus various arts and crafts goodies to make a veritable army of whirring and walking mechanical denizens.

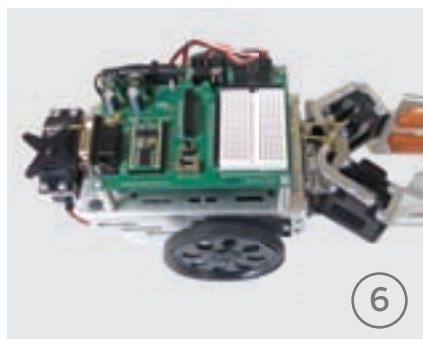
You get some pre-cut stiff paper to construct the robot body – these bots are made of squares and cylinders, and you can combine parts to suit your fancy. Add stickers, pushpins, and googly eyes, then mix in a highlight or two from the assortment of colored pens so thoughtfully stashed in the kit.

With enough parts to make five fully autonomous wandering robots, this one's great for a whole family – cold or rainy day optional. Good for kids 7 and up, with adult supervision recommended for younger children.



A SOLDERLESS BREADBOARD ON WHEELS — ONE OF MY FAVORITE WAYS TO PLAY WITH ROBOTICS.





4. QuadBot

Dagu Electronics $50
robotshop.com

Complexity	1
Components	4
Documentation	3
Community	3
Completeness	3

Eight mini servo motors and an assortment of acrylic pieces combine to create the QuadBot, a low-cost, four-legged robotic pet you can assemble in under an hour. The kit doesn't come with brains or batteries; add those yourself. Each leg uses two servos, making this a 2DOF (two degrees of freedom) walkerbot.

Exercising a bit of overkill, I tried out my QuadBot using a Dagu Spider controller, which can run up to 48 servos. For a less expensive option, try an Arduino Uno coupled with a servo shield.

QuadBot is tricky to program, but its designer, Russell Cameron, provides numerous examples on letsmakerobots.com under the username OddBot.

As with other walking robots, you should watch battery weight. Use small NiMH cells, not alkalines. I got 15 minutes of playtime with two 3×AAA packs wired in series on the underside of the robot.

5. MadeUSA Robot Base Full Kit

Parallax $880
parallax.com

Complexity	5
Components	5
Documentation	5
Community	4
Completeness	3

Around my house I've renamed my MadeUSA "Big Bruiser" for the black and blue marks it leaves on my ankles when it runs into me during programming tests. Chalk it up to an occupational hazard. And besides, I got these bruises while having fun.

This bot, which is strong enough to cart around a full-grown person balancing on its ⅝"-thick HDPE deck, runs on a pair of automotive power window motors and pneumatic rubber wheels.

The kit comes with motor drivers and ten (count 'em!) Ping ultrasonic rangers that ring the base and give the robot its mythological Medusa look. You supply the battery, switches, fuses, and microcontroller – I've used both an Arduino Mega 2560 and a Parallax Propeller. The motor drivers are controlled via serial commands, and their position encoders let you specify travel distances before a stop or turn.

6. Boe-Bot Robot and Gripper

Parallax $160 and $56
parallax.com

Complexity	2
Components	5
Documentation	5
Community	5
Completeness	4

I bought my first Boe-Bot over 10 years ago. I've dropped it, stepped on it, even lost it behind the couch for three months. Nothing seems to faze this thing.

The Boe consists of an aluminum frame, upon which two servomotors, a battery holder, and a BASIC Stamp 2 microcontroller board are mounted.

Over the years Parallax has developed numerous add-ons. One I like best is the servo-operated gripper, which makes the Boe-Bot look like a nasty pincher bug. The gripper can lift small objects like chess pieces and ping pong balls, but it won't fetch a beer – unless it's a very small beer from a very short fridge.

Suitable for first-time builders, the Boe-Bot takes about 2 hours to build. The gripper kit requires a bit more skill; plan on another hour. Other nifty accessories include a six-legged walker kit and an infrared line-following module.

ROBOTICS

7. 3-in-1 All Terrain Robot

OWI $50
owirobot.com

Complexity	2
Components	4
Documentation	4
Community	2
Completeness	5

I've been building OWI robot kits since the mid-1980s. Some have been good, a few not worth the box they came in. Every once in a while, OWI does a kit that's great – their 3-in-1 All Terrain Robot (ATR) is one of these.

This entertaining kit, suitable for kids 12 and up, lets you build three different tracked robots. You start by assembling separate modules, then snap the modules together to create a rover, forklift bot, or gripper crawler. You can always unsnap the modules and reconfigure them for another style. I built the forklift version, spending about three hours while watching reruns of *Star Trek*. The assembly manual is clear and concise, with great 3D pictures to show how things go together.

The robots are motorized using a wired control box. Two motors operate the left- and right-side tracks, while a third motor operates an extended mechanism – the forklift goes up and down, for example, and the gripper opens and closes.

The ATR is immensely hackable, thanks to its modular design. Unplug the 4-pin connector from the control box, and substitute your own microcontroller. Looks like there's just enough room on top for an Arduino, a motor shield, and some LiPoly batteries. Seems like I'll be watching more *Trek* episodes!

8. AL5B Robotic Arm Combo Kit

Lynxmotion $311
lynxmotion.com

Complexity	5
Components	5
Documentation	4
Community	4
Completeness	5

Ready for a challenge? Try one of the robotic arms from Lynxmotion. I got their AL5B arm kit, which sports a 5oz lift capacity, five joints, and a reach of 7½ inches. I assembled it in one evening, and I've been having a blast with it ever since.

All arms in the product line are based on the company's Servo Erector Set parts. These are prefab aluminum pieces designed to mate with standard R/C servomotors. You can buy SES parts separately, too, for your own arm designs, or to modify one of the stock arm models.

The AL5B is for experienced builders. The hardware comes in numerous bags, and it can be a trick keeping track of everything. I suggest you open each bag only when you need it, and keep a measuring tape nearby to check the length of screws. Study the online assembly instructions ahead of time while you wait for your kit to arrive. The kit doesn't require soldering, but needs a base you supply. I used a piece of ½"-thick plastic.

Included in the AL5B kit is Lynxmotion's SSC-32 servo controller board. Connect it to your PC (via serial cable or USB-to-serial adapter), and run the free FlowArm software to control the motion of each joint. Record complex motions and play them back with the click of a button.

Maker SHED

Herbie the Mousebot

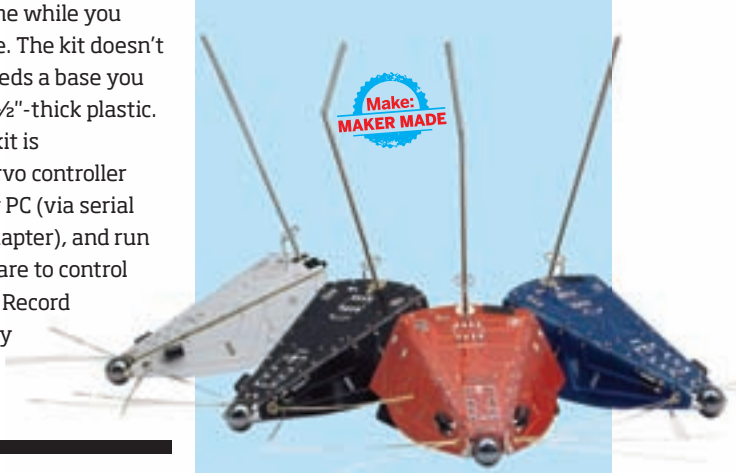
Maker Shed $40
makershed.com MKSB001

Complexity	2
Components	4
Documentation	5
Community	3
Completeness	4

I built this Mousebot with my son, who had just turned 10. At first, I had to show him how to solder and helped him align the sides (not too easy), but by the end he was doing all the work himself and enjoying the "toughness" of the assembly. This kit is simple, but it demands attention to detail. The fun directions include jokes for kids and adults. All in all, this is a great starter kit, but you'll need a nice soldering iron.

To get Herbie to work, we did have to change a few things from the directions. They tell you to use double-sided foam tape (provided) to attach the motors. However, when we did that, we couldn't fit the battery in. We just removed the tape, reheated the solder to move the motor closer to the board, and glued it on with Sumo Glue. We also discovered that Herbie will not follow LED flashlights; they just don't put out enough infrared.

–Ryan Pederson



MY LIVING ROOM LOOKS LIKE DARWIN'S LABORATORY.

9

10

11

12

9. Topobo

Topobo $149
topobo.com

Complexity	2
Components	5
Documentation	3
Community	1
Completeness	5

My living room looks like Darwin's laboratory. A three-legged creature writhes on the floor. My daughter pulls off a leg and connects it to its face. My son teaches it to walk. It's really moving now! This is how you play and learn with Topobo.

Topobo is part construction toy, part kinetic memory robot. By combining solid parts with active motor/brain hubs (learning servos) you can spend hours creating unlikely creatures with even more unlikely forms of locomotion.

My young kids immediately got how to record and play back the motion of their creations; press a button, perform a few poses, press the button again, and it's alive! I wanted to save movements between sessions, but my kids understood before I did that Topobo is about exploring novel methods of movement, not reproducing past creations.

Our only complaints: the Lego Technic-compatible connectors are hard to remove, and we'd prefer batteries to being tethered to the wall with the power supply wire. *–John Edgar Park*

10. Sumovore Mini-Sumo Robotics Platform

Solarbotics $99
solarbotics.com

Complexity	4
Components	5
Documentation	3
Community	5
Completeness	4

This is one of the most satisfying kits I've ever built, and the Sumovore it creates will be eligible for official RoboGames Mini-Sumo competitions, in which robots vie to push each other out of the ring.

This is not a project for beginners, but thanks to clear documentation and well-organized components, anyone with moderate soldering skills and sufficient patience shouldn't have much trouble. It ships with analog "discrete brain" circuitry, but "brainboard" kits let you add popular microcontrollers.

–Gareth Branwyn

11. Lego Mindstorms NXT 2.0

Lego Mindstorms $280
makershed.com JM2082644

Complexity	2
Components	5
Documentation	5
Community	5
Completeness	5

This latest version of Lego's popular Mindstorms robotics kit includes a new 3-in-1 color and light sensor with LEDs; a new ball shooter; and tank treads. On the software side, an image editor now lets you convert your own images to fit the LCD display, and a sound editor records and converts sound clips, to play through the speaker.

Most useful of all, a remote control menu offers direction and speed control for two motors and an action button to control one motor independently. This lets you test motors without having to program anything!

I'd like to see more programmable storage memory, but overall this is a nice refresh for Mindstorms NXT. It's an excellent kit for budding robot enthusiasts and also a great gift for veterans. *–Eric Chu*

12. Metabots

EnjoyMobil $6–$20
amazon.com

Complexity	2
Components	4
Documentation	3
Community	1
Completeness	5

The box contains nothing more than a few sheets of die-cut foamcore, a dozen plastic ball joints, and instructions. But what they create, after some punching out and slotting together, are some of the coolest-looking posable robot action figures on the market today. Available in an all-white "prototype" version ripe for customization. *–Sean Michael Ragan*

ELECTRONICS & CONTROLLERS

THE PERFECT GATEWAY KIT.

LEARN TO SOLDER SKILL BADGE

Maker Shed $3
makershed.com MKLS01

Complexity	1
Components	5
Documentation	5
Community	5
Completeness	5

Thousands of people mastered soldering for the first time at this year's Maker Faire events in the Maker Shed's "Learn to Solder" tents, with the helpful coaching of Mitch Altman, Jimmie Rodgers, and dozens of other hackerspace volunteers. Participants left the Maker Shed with smiles on their faces, new skills, increased confidence, and a cool flashing LED badge to show for it. It's the perfect gateway project kit for groups, after-school classes, or just for yourself. *–Dan Woods*

See the build at:
makeprojects.com/project/m/82

BUILD OVER 500 SNAP-TOGETHER CIRCUITS!

SNAP CIRCUITS PRO

Elenco $90
makershed.com MKEL11

Complexity	2
Components	4
Documentation	5
Community	3
Completeness	5

The award-winning Snap Circuits Pro 500 Experiments kit contains more than 75 parts and detailed project books that allow you to build over 500 snap-together circuits – no tools required. You can assemble a musical doorbell, laser gun, race game, lie detector, electronic kazoo, mind reading game, telegraph, AM/FM radio, and so many more projects. For ages 8 and up; student/teacher guides are available at snapcircuits.net.

LIKE LEGO FOR BASIC CIRCUITS.

LITTLEBITS STARTER KIT

littleBits $130
makershed.com MKLB1

Complexity	2
Components	5
Documentation	5
Community	4
Completeness	5

The littleBits kit is like Lego for basic circuits. Each "bit" is a small circuit board that enables a single electronics component or electronic function, like a potentiometer, light sensor, LED, or motor. The bits snap together magnetically with edge connectors that are color-coded to indicate their general role within a circuit; for example magenta means input, green means output, and blue means power. The magnets are oriented so that you cannot connect the bits the wrong way, and three spring-loaded contacts in each connector carry voltage, signal, and ground from bit to bit. This clever design makes experimenting with series circuits easy and "wireless." *–Paul Spinrad*

Solder or snap together devices that do things, control gadgets, and improve your life.

GET INTO YOUR APARTMENT WIRELESSLY AND KEYLESSLY.

HD2COMBO REMOTE CONTROL RELAY

Carl's Electronics $30
electronickits.com

Complexity	2
Components	4
Documentation	5
Community	1
Completeness	4

Don't tell the co-op board, but I now use this RF fun relay kit to get into my apartment building wirelessly and keylessly, by hacking into its intercom system, which lets you buzz people into the front door.

The kit consist a small printed circuit board and a key fob remote. After enclosing the PCB in a small project box, I simply wired one of its two relays to my intercom's two Door terminals.

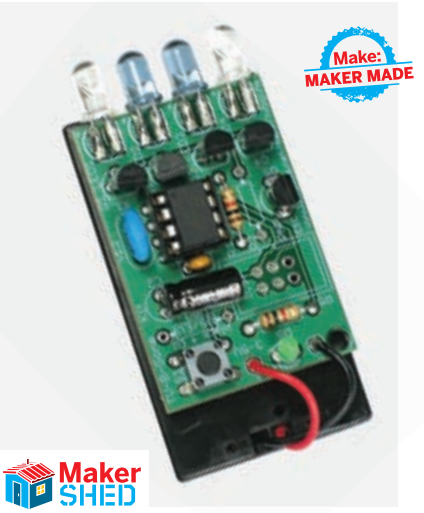
After powering the board up and performing the learning procedure for the remote, the system was ready to go.

My apartment is on the second floor directly above the entry, so the 250-foot range on the transmitter fob is not an issue.

And there you go: a keyless entry. I just buzz myself in. And it's a rolling code transmitter, so no, not just anyone with a remote can activate the relay.

–Ryan O'Horo

ZAP SCREENS FROM ACROSS THE STREET.



TV-B-GONE KIT

Adafruit Industries $25
makershed.com MKAD4

Complexity	3
Components	4
Documentation	5
Community	4
Completeness	5

Tired of all those TVs everywhere? Want a break from advertisements while you're trying to eat? Want to zap screens from across the street? The TV-B-Gone kit is what you need. The new v1.2 works worldwide, turning off virtually any TV by running 230 TV power codes for Asian/North American and European IR remote standards. Built by Adafruit in co-operation with TV-B-Gone inventor Mitch Altman, this kit is a great way to build something truly useful. Check out the excellent tutorials and forums at adafruit.com.

MAKE Disclaimer: "Please use your TV-B-Gone for good and not evil (unless it's funny, and even then we don't necessarily condone it)."

See the build at:
makeprojects.com/project/t/637

KIT MAKER

ADAFRUIT INDUSTRIES
LIMOR FRIED

adafruit.com

Adafruit Industries was founded in 2005 by electrical engineer Limor Fried. Based in New York City, Adafruit makes fun and educational open source electronics kits with superb documentation. Big hits include a backup iPhone charger called the Minty Boost, and TV-B-Gone, a universal remote that powers down nearby television sets.

Because Adafruit publishes all source files and documents its kits well, an active community has grown around it, with participants constantly sharing derivative designs. Adafruit also hosts a weekly streaming video show, "Ask an Engineer," where Fried fields electronics questions and shows off new kits.

Limor received a Pioneer Award from the Electronic Frontier Foundation (EFF) in 2009, and in April 2011 she was featured on the cover of *Wired* magazine's "How to Make Stuff" issue.

–Becky Stern

MICROCONTROLLERS

JUST PLUG, PLAY, AND LEARN.

Maker SHED

GETTING STARTED WITH ARDUINO KIT V3.0

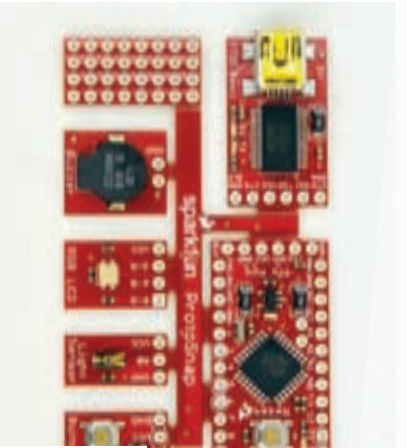
Maker Shed $65
makershed.com MSGSA

Complexity	3
Components	5
Documentation	5
Community	5
Completeness	5

The world of Arduino microcontrollers can be a challenge to break into – but not if you're equipped with this kit, which includes all of the hardware you need to work through each of the experiments in *Getting Started with Arduino*, the popular introductory book by Arduino project co-founder Massimo Banzi. To make it even easier, all of the components are solder-free, except for the DC plug and battery pack – just plug, play, and learn. Not only does the book go over all of the Arduino's features, it also gives a good overview of basic electronics. After completing this kit, I found myself ready to take on all sorts of physical computing projects.

–Tyler Moskowite

A GREAT KIT FOR ARDUINO LOVERS OF ALL EXPERIENCE LEVELS.



Maker SHED

PROTOSNAP PRO MINI

SparkFun Electronics $45
makershed.com MKSF8

Complexity	2
Components	5
Documentation	5
Community	4
Completeness	4

The ProtoSnap Pro Mini is one of the more interesting Arduino kits. Manufactured on a single PCB, it includes a preassembled Arduino Pro Mini (0.7"×1.3") and snap-off accessory boards like an FTDI Basic Breakout board, buzzer, RGB LED, light sensor, pushbutton, and a general-purpose protoboard for wiring up your own custom components. Snap off each piece, and you'll see there are holes to solder pins, wires, or however it needs to connect. Then you can load your project's sketch onto the Pro Mini immediately to start testing. Finally, the documentation is concise, for those just getting started with Arduino, and even enjoyable to read. This is a great kit for Arduino lovers of all experience levels.

–TM

ADD NEW I/O'S TO YOUR ARDUINO UNO.

Maker SHED

EZ-EXPANDER SHIELD

Nootropic Design $14
makershed.com MKNTD1

Complexity	3
Components	5
Documentation	5
Community	4
Completeness	4

When working with the Arduno Uno, I often find myself needing more output ports than it's got. Instead of having to trade my Uno for an Arduino Mega, I just plug in an EZ-Expander Shield, which plugs into three I/O ports and furnishes 16 – instantly providing 13 more I/Os. While each added pin can only safely consume about 6mA, this is still enough to drive LEDs or operate transistors. The documentation of this kit is extremely well done, with clear directions and photos. Assembly was a breeze. And with the provided libraries, you only have to add one line of code to your sketch to use your new expansion pins.

–TM

USE FOR QUICK FIXES OR COMPLETE ELECTRONICS PROJECTS.

MINTRONICS BUNDLE: MINTDUINO + SURVIVAL PACK

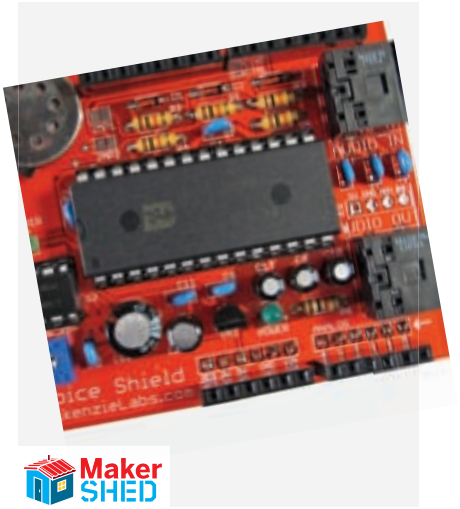
Maker Shed $45
makershed.com MSBUN24

Complexity	3
Components	4
Documentation	3
Community	4
Completeness	4

The Mintronics Bundle from the Maker Shed is a great way to get started with Arduino and electronics. It includes a MintDuino – a mint tin containing all the components you need to build a full-featured Arduino-compatible microcontroller – plus the Mintronics Survival Pack, another tin containing over 60 über-handy components you can use for quick fixes or complete electronics projects. (To upload your programs onto the ATmega328P microprocessor, you'll also need an FTDI programmer like the FTDI Friend.)

See the build at:
makeprojects.com/project/t/608

BUILD DEVICES THAT TALK, SING, OR PLAY MUSIC.



VOICE SHIELD

Spikenzie Labs $46
makershed.com MKSKL3

Complexity	3
Components	5
Documentation	4
Community	4
Completeness	4

The Voice Shield is an analog audio shield for Arduino and compatible boards that allows you to play audio files saved in WAV format, whether short sound bites or entire operas. It lets you easily add audio to your next microcontroller project, thanks to a unique and very user-friendly way to access different sound clips. Use this shield to build devices that talk, sing, play music, or have sound effects.

LIMITLESS POTENTIAL FOR PROJECTS.

ARDUINO ADK TINKERKIT

Arduino $359
makershed.com MKSP10

Complexity	5
Components	4
Documentation	2
Community	3
Completeness	4

Android rocked the physical computing landscape last spring when it announced the Android Open Accessory Development Kit (ADK), an Arduino-based platform that combines the brains and connectivity of the Android with Arduino's wealth of open source wares for controlling physical devices. The ADK presents almost limitless potential for projects.

Now the ADK TinkerKit unleashes this potential with the new Arduino Mega ADK (also sold separately for $85), which interfaces with an Android device via a USB host, and a multitude of modules such as LEDs, relays, joysticks, potentiometers, touch and temperature sensors, and many more. One caveat: the documentation on how to work with this technology, which bridges the Arduino and Android environments, is still sparse, and working with this kit is not for the faint of heart.

–TM

ELECTRONICS & CONTROLLERS

OVER 100 COMPONENTS COVERING ALL THE BASICS.

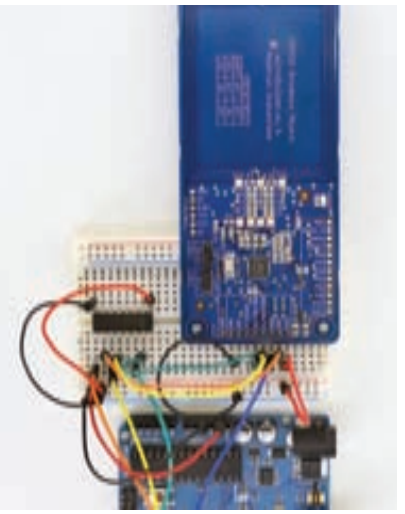
ULTIMATE MICROCONTROLLER PACK

Maker Shed $120
makershed.com MSUMP

Complexity	4
Components	5
Documentation	3
Community	4
Completeness	5

You can find an endless number of cool microcontroller projects and tutorials online these days. The tricky part is finding one that matches the components you already have or sourcing what you need to tackle that awesome project you're dying to sink your teeth into. So the MAKE staff designed this pack with everything they wanted for their own microcontroller projects. From the Maker Shield prototyping shield to an LCD screen; breadboards to force resistors; tilt sensor to mini DC motor, and pretty much every resistor, capacitor, and basic LED, this pack has over 100 components covering all the basics and the fun stuff too. It's an awesome pack for both beginners and advanced users, which is why it's available with Arduino Uno, Netduino, Netduino Plus, or no microcontroller at all. *–DW*

DO IT ALL WITH NFC AND RFID.



NFC/RFID CONTROLLER BREAKOUT BOARD

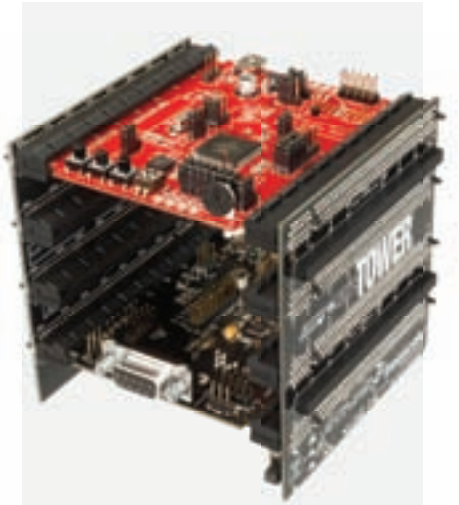
Adafruit Industries $50
adafruit.com

Complexity	3
Components	4
Documentation	3
Community	5
Completeness	3

In the next few years there's going to be an influx of a not-so-new technology called Near Field Communication (NFC), which is very similar to RFID, and enables small devices to read passive tags and communicate with each other in close proximity. Card readers use it, as do phones that do payment processing.

Adafruit's PN532 NFC/RFID controller breakout board v1.3 can do it all with NFC and RFID, reading types 1 to 4 of both standards. The board provides read and write communication though 3.3V TTL UART at any baud rate, I2C, or SPI, and is supported by the open source general NFC library *libnfc*. The device-specific Arduino library provided by Adafruit currently only supports a read function, but there are plans to expand it. *–TM*

FEEL THE TOWER'S POWER.



FREESCALE TOWER MICROCONTROLLER SYSTEM

Freescale Semiconductor $99
freescale.com/tower

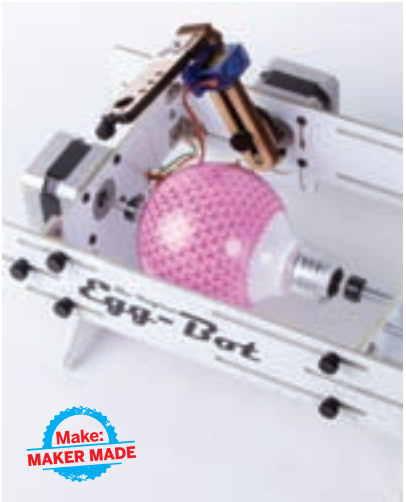
Complexity	4
Components	5
Documentation	4
Community	3
Completeness	5

Got a project to prototype? Freescale's Tower system with its Real Time Communications Suite (RTCS) offers greater processing power and more programming resources than Arduino, although it takes longer to learn.

The basic kit consists of the 32-bit microcontroller board with USB and RS-232 interfaces, accelerometer, four display LEDs, switches, and a potentiometer. Additional modules include different microcontrollers, LCD display, and sensor, wi-fi, and prototyping boards.

After trying the tutorials, I wired a solderless breadboard with light and temperature sensors to the Tower's side expansion port, then modified the code to read the sensors via the internet. No soldering! Freescale's documentation makes development easy, and the community at towergeeks.org can help you over the bumps. *–L. Abraham Smith*

ONE MORE TOOL IN THE EGG DECORATOR'S ARSENAL.



EGG-BOT

Evil Mad Science $195 to $220
evilmadscience.com

Complexity	4
Components	5
Documentation	5
Community	4
Completeness	4

The Egg-Bot is an art robot designed by Bruce Shapiro that's fun to watch as it draws intricate designs on eggs or any other round objects 3cm–10cm in diameter, including ornaments, golf balls, and light bulbs. You design the patterns in the free app Inkscape, and the bot draws them using fine-point Sharpies, engraving tools, or other implements. The decorated eggs come out so beautiful that people have asked whether using an Egg-Bot is "cheating." A healthier attitude is to think of the Egg-Bot as one more tool in the egg decorator's arsenal.

This kit includes the fiberglass chassis, all stepper and servomotors and other parts, and the fully assembled and tested USB motor driver board; you provide computer, egg, and pen. A deluxe kit adds shiny brass hardware, no-slip egg gripper, and a ball driver.

–PS

RETROCOMPUTING

Apple I Replica Kit

Briel Computers $149
brielcomputers.com

Complexity	4
Components	4
Documentation	4
Community	5
Completeness	4

Hobbyists are rediscovering the appeal of classic microcomputers from the 70s and early 80s, eager to tinker with computers at their fundamental level.

Vince Briel designed the Replica I with permission from the Apple I's original creator, Steve Wozniak. He sells it assembled ($199), as a kit ($149), or just the motherboard and specialized chips ($79). (Alternatively, the schematic, PCB layout, and fabrication documents – enabling you to build a system from scratch – are included with my book *Apple I Replica Creation*.)

The Replica I is built around the same 6502 microprocessor used in the Apple I, Apple II, Commodore 64, Atari 2600, and NES. The design has three parts: processor section, video section, and PS/2 interface. (The PS/2 interface is peripheral; an ASCII keyboard works just as well, and can be connected directly to the processor section.)

The processor section consists of the 6502 processor, a 6821 peripheral interface adapter that controls all the I/O, a 32KB RAM chip, an 8KB ROM chip, and three TTL chips. The keyboard provides ASCII input to the 6821, which passes it along to the processor. To display text on the screen, the processor sends ASCII to the 6821, which in turn passes it (as ASCII) to the video section.

The Apple I had no graphics support and was unable to edit text once it was sent to the video section, which served as a dumb terminal. The Replica I uses a Parallax Propeller to send video to TV, and there are hacks to redirect video output to a printer or teletype.

The Apple I is about as simple as an 8-bit microcomputer can get, and hacks and projects for it abound. Larry Nelson has ported a floating point BASIC to the Apple I. Vince Briel designed a serial interface card, ported the classic 70s game *Star Trek*, and recently added user firmware updates to the Replica I – no need to send in for new chips. Ken Wessen added a full-blown assembler to the EPROM, letting the user assemble 6502 programs right on the Replica I without a PC.

Mike Willegal (willegal.net) sells a replica Apple cassette interface kit for loading programs from tape (he also sells an all-vintage Apple I clone called the Mimeo 1 for, yes, $666.66). Others are replacing cassettes with iPods.

The Apple I Owners Club (applefritter.com/apple1) serves as the meeting place for retrocomputing enthusiasts. Ideas are exchanged, hardware is built, and software is written. If you're interested, I hope you'll join us.

–Tom Owad

LEDs

KIT MAKERS

WAYNE AND LAYNE

wayneandlayne.com

Adam Wayne Wolf and Matthew Layne Beckler met in 6th grade and quickly began collaborating over such geeky pursuits as K'Nex logic gates and microcontrollers. They were roommates at the University of Minnesota, earning degrees in computer engineering before moving on to grad school. Eventually, their friendship evolved to include a business partnership.

Their first product was the Tactile Metronome Kit. "After selling our first batch of kits, and even making a profit, we decided to turn our business experiment into an actual business in the spring of 2009," Wolf says.

Their next kit, the Video Game Shield, turns an ordinary Arduino into a video game machine. As an open source project, users can create and share their own games for the shield.

Since then, W&L have come out with a line of innovative kits and plan to do some work with Android and Arduino in the future, as well as add features to their Blinky kits. Stay tuned!

–John Baichtal

Add human ingenuity, and you get countless simple, hackable circuits that do amazing things with bright, colorful "das blinkenlights."

1. Red Blinky POV

Make: MAKER MADE

Wayne and Layne $16
makershed.com MKWL03

Complexity	3
Components	5
Documentation	5
Community	3
Completeness	5

This kit is amazingly cool and easy to use. POV (persistence of vision) displays show words or patterns that seem to float in mid-air; if you've ever seen one, you know what a great effect it is. A line of LEDs flashes the Y component of what you're displaying, and you provide the X by moving across the field of view – now you see it, now you don't. With the Red Blinky POV, you don't need to do any programming to set the message you want to display: just enter your text into a dedicated web page and hold the Blinky up to your monitor. The onboard pre-programmed microcontroller and light sensors on the back eliminate the need for a programming cable.

–Paul Spinrad

2. Conway's Game of Life

Adafruit Technologies $18
makershed.com MKAD3

Complexity	2
Components	5
Documentation	5
Community	4
Completeness	5

Our family reunions have become quite an affair now that my mother can tally 21 grandkids. Aged from 1 to 20, keeping them busy is a challenge. At last year's reunion I brought a small LED craft project for the little kids, but I needed something more challenging for the older ones. Luckily, I came across this Game of Life Kit.

The Game of Life, as proposed by John Conway in 1970, is not really a game, but it's fun to watch. From an initial pattern on a grid, it dictates simple rules that govern the life or death of each square. Through successive iterations, amazing shapes evolve, and the larger the grid, the more elaborate the patterns.

At the reunion, I pulled kids aside two at a time, gave them a brief lesson on soldering, and then let them try their hand at it. Then, as each kit was finished and tested, we attached it to the boards that were already assembled, where they communicated with one another, allowing more elaborate patterns to form. We wound up with ten boards all working together, and the assembly was as mesmerizing as the campfire. As each family prepared to leave at the end of the reunion, I gave each kid their board to take home.

–Ken Olsen

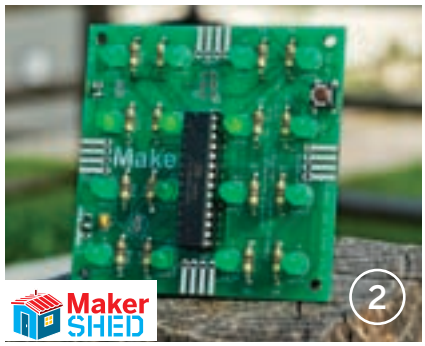
3. Meggy Jr RGB Game Console

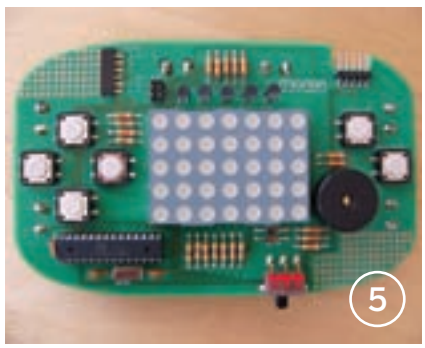
Evil Mad Science $75
evilmadscience.com

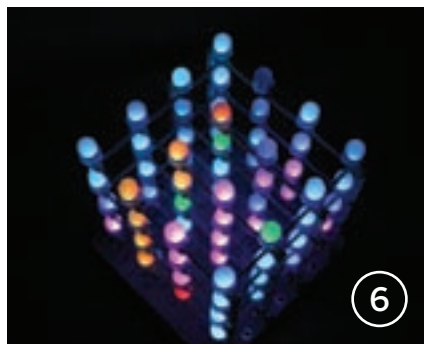
Complexity	2
Components	5
Documentation	5
Community	3
Completeness	5

This pixel-scale, portable Meggy Jr game platform is fun for any gamer, especially those who know their way around an Arduino. About the size of a VHS tape, it offers an 8×8 matrix of RGB LEDs and a lot of functionality with very little setup. It comes pre-programmed with *Attack of the Cherry Tomatoes*, a side-scrolling pixel shooter, and its USB-TTL interface lets you program your own rockin' pixel game. As with most Evil Mad Science products, a dedicated wiki provides all the documentation to hack, mod, or customize your handheld any way you like.

–Tyler Moskowite







NERDY BUT GORGEOUS ACCENT LIGHT.

4. Octolively

Evil Mad Science $35
evilmadscience.com

Complexity	2
Components	5
Documentation	5
Community	3
Completeness	5

The Octolively is one of the most entertaining kits I have built in a while. It's an interactive, tileable LED module that carries eight huge (10mm) LEDs arranged on its 4"×8" board. Its sensors detect nearby movement using both infrared and visible light, and the LEDs, which come in a variety of colors, respond with eight preprogrammed behaviors you select with a button. You can also use an AVR programmer to program custom behaviors or install firmware updates. The Octolively modules run off 5V DC and can be installed almost anywhere. *–TM*

5. Mignon Game Console

Mignon €52 (about $69)
mignongamekit.com

Complexity	5
Components	5
Documentation	4
Community	3
Completeness	4

Although 5×7 pixels aren't a lot to work with, it's easy to get lost in Olaf Val's Mignon Game Kit. This minimalist handheld gaming system is hands-on in more ways than one. The first step is to put it together; second is to hack code for the Atmel ATmega8 microcontroller that powers it; and third, you get to play with it. With a four-way directional pad and two function buttons, the Mignon is ready for some serious, if extremely basic, gaming.

The Mignon is complex enough to be interesting, but not so complex that a child would have trouble with it. It's a perfect microcontroller kit for hardware hackers of all ages (provided you've got the appropriate supervision for the soldering at the lower end of that age scale). But with just over 100 solder joints, make sure to set aside a few hours for assembly, especially if this is your first major soldering endeavor.

There are two games stored in the ATmega8's nonvolatile RAM, *Maze Driver* and *Min Pong*, which hopefully will get overwritten soon with your own programs.

For programming, use any compiler that supports the ATmega8; BASIC and C are popular choices. You access the bootloader through a 9-pin D-Sub serial port, so computers lacking USB will need a serial adapter. Like the Mignon as a whole, its programming interface is extremely simple and does not require any tricky-to-use separate hardware programmer. *–Brian Jepson*

6. Rainbow Cube

Seeed Studio $60
seeedstudio.com

Complexity	4
Components	5
Documentation	4
Community	5
Completeness	4

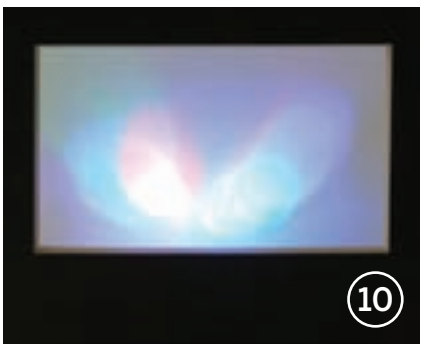
The Rainbow Cube is a nerdy but gorgeous accent light consisting of a 4×4×4 cube of red-green-blue LEDs. Depending on how it's programmed, colors appear to move, pulse, or wash through the cube in all directions, which is fascinating to watch. The LEDs connect to the PCB base via an ingenious structure consisting of thin PCB supports. I only had a little bit of experience soldering before I made this kit, but I was able to successfully solder it in two hours.

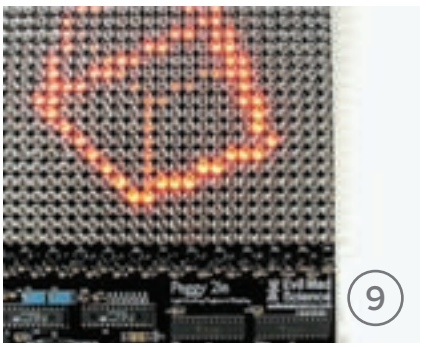
The cube comes preprogrammed with a simple gradient, but there are a lot of fun, full-motion programs online, and of course you can write your own. To make the cube work, you'll also need a Rainbowduino LED driver board ($20), which attaches to the cube to control the colors.

–Amanda Nix

Amanda Nix (6)

LEDs





TRANSFORM A SIMPLE BATTERY HOLDER INTO A FULLY FUNCTIONAL MINI LED FLOODLIGHT.

7. Trippy RGB Waves

Cornfield Electronics $10
makershed.com MKCE4

Complexity	2
Components	5
Documentation	5
Community	3
Completeness	5

Do you like interactive art? Imagine a bunch of little lights on a table, each about the size of a chess piece, each independent of the others. Arrange them any way you want. Each light continually and slowly changes colors on its own – but when you wave your hand over them, they create waves of colors that follow your hand. Trippy!

To go deeper, a 6-pin ICSP interface lets you use an AVR programmer or Arduino to reprogram each light's behavior. To sense proximity, the lights use an infrared LED and IR detector. This is another awesome and affordable kit from Mitch Altman, the creator of the TV-B-Gone and the Brain Machine.

8. LED Video Light

ProdMod $35
makershed.com MKPM3

Complexity	3
Components	5
Documentation	3
Community	1
Completeness	4

Have you tried taking video using your digital camera but never seem to have enough light? Does your camera have trouble focusing in the dark? LEDs are cheap, and so are resistors, so why not make your own LED Video Light? With this second-generation kit from ProdMod, you'll transform a simple battery holder into a fully functional mini LED floodlight that you can attach to your digital, film, or video camera. It runs more than seven hours with three AA batteries, and it's so slim that you can slip it into your pocket or purse and use it as a wide-angle flashlight.

9. Peggy 2LE

Evil Mad Science $75
makershed.com MKEMS3

Complexity	3
Components	5
Documentation	4
Community	4
Completeness	2

Peggy 2LE provides a quick, easy, powerful, and efficient way to drive a lot of big, bright LEDs – up to 625 – in a matrix. With it, you can make an LED sign for your window, a geeky valentine for your sweetie, one badass birthday card, the next generation of low-pixel-count video games, or even outdoor signs that (as has been shown) can freak the holy bejesus out of the city of Boston. Your call. The display can run off batteries or the included AC adapter, and is designed to drive as many LEDs as you care to solder into its holes, any colors, standard 3mm or 5mm sizes. LEDs not included.

10. LED Art Kit

Murphlab $20
makershed.com MKKM2

Complexity	1
Components	4
Documentation	5
Community	2
Completeness	5

This easy-to-assemble, no-solder kit lets you create your own unique LED light show. The only tool needed is a pair of pliers for crimping the wire connectors. The RGB (red-green-blue) LEDs create a slow, ever-changing, multicolored glow that's perfect for setting the mood of any room. Makes a great nightlight, too!

RADIO-CONTROLLED VEHICLES

From extreme rock crawlers to autonomous quad copters, the state of the art in radio-controlled vehicles is available to any maker in these great kits.

Killer Krawler

RC4WD $700 chassis kit, $1,300 ready to run rc4wd.com

Complexity	3
Components	5
Documentation	2
Community	3
Completeness	3

In my opinion the coolest innovation in R/C vehicles is the crawler. As the name implies, crawlers are incredible crawling machines that are super fun to build and to run. Like a good video game, they're easy to pick up but hard to master. Crawlers are built to climb over serious terrain, and some are built as scale trucks that look as realistic as possible (while still being monster crawlers). There's no shortage of stuff to climb, from backyard rocks to your living room couch.

RC4WD's Killer Krawler is one of the biggest such models in the world. At 1/5 scale, it has a fully CNC-machined aluminum chassis, an articulation angle of 90°, nearly 6 inches of center ground clearance, and an over 22-inch wheelbase.

As with all crawlers, this one is four-wheel-drive, with locked differentials. It has two motors, one on each axle, aka MOA (motor on axle). The gears, along with everything else on this beast, are all billet aluminum, so it'll withstand anything you can throw at it. The 30:1 gear ratio ensures high torque for precise crawling. Two ESCs (electronic speed controllers), two motors, a radio system, servo, and a battery are required to complete this kit.

The giant scale of the chassis kit makes it attractive as a potential robotics platform, able to handle extremely rough terrain and big enough to carry a truckload of sensors and hardware. RC4WD has hundreds of options and parts to choose from — wheels, tires, chassis, shocks, axles, transmissions, and electronics — to help you easily customize a truck of your choice.

—I-Wei Huang

R/C VEHICLES

BY MICHAEL CASTOR,
MAKER SHED EVANGELIST

THE DIY DRONES COMMUNITY IS THERE TO HELP AND THEY'LL PUSH YOU TO EXPAND.

1

2

3

1. ArduCopter 3DR Quadcopter

DIY Drones $589
store.diydrones.com

Complexity	4
Components	4
Documentation	4
Community	5
Completeness	4

Quadcopters rely on computer stabilization to fly. They can be radio controlled, but with an onboard computer, why not let it fly itself? The community at DIY Drones (*see page 26*) developed the open source ArduPilot Mega (APM), an Arduino-based autopilot that lets you control multi-rotor (and other) aircraft autonomously, or via R/C.

The ArduCopter 3DR Quad Kit with Electronics includes everything to build your own quad UAV, except radio gear and batteries. Directions are easily downloaded, and assembly is relatively painless; just take care to put thread-locker on all screws, and balance the props. A wiki walks you through the Mission Planner software, firmware installation, and calibration of the APM board, sensors, and speed controls.

In autonomous mode, the ArduCopter takes off, follows GPS waypoints, and lands unassisted. In manual mode you fly it by the remote and make it hover ("loiter") by flipping a switch. The DIY Drones community is there to help and they'll push you to expand – add video or use a ground control station to wirelessly upload new coordinates – so you'll never tire of your ArduCopter.

2. T-IFO Indoor Trainer

Wild R/C $54 and up
wildrc.com

Complexity	2
Components	4
Documentation	4
Community	3
Completeness	3

This unique, rugged R/C trainer is assembled by bending carbon fiber rods, binding with Kevlar thread, and then covering with polyester fabric. The build takes an evening or two; add a radio, servos, and batteries, and enjoy a remarkably good airplane for beginners and experienced pilots. Plus, it folds flat, so you can take it anywhere!

3. 66-inch Indoor Blimp

Mobile Airships $347
rcguys.com

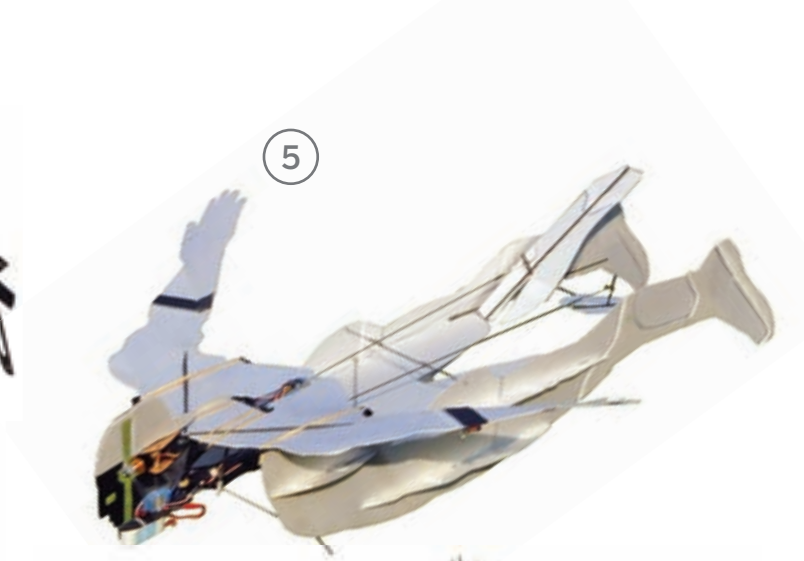
Complexity	2
Components	4
Documentation	4
Community	3
Completeness	3

Who doesn't love blimps? They're quiet and slow but leave a huge impression. This kit goes together easily using basic hand tools and the included directions, and has almost everything you need to get airborne; you supply R/C gear, servo, battery, and helium.

The vinyl balloon can be decorated with paints or computer-cut graphics, which is perfect for sporting events, trade shows, or just for fun.

Add a few coins for ballast, and you can fly the blimp indoors with precision by using a gentle hand on the controls. In flight it looks amazing, just like a smaller version of the real thing.

6



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7

4. Trail Finder Truck

RC4WD $300
rc4wd.com

Complexity	2
Components	5
Documentation	2
Community	3
Completeness	3

This 1/10 scale kit has amazing realism and performance, with aluminum and steel chassis and body components like those of a full-sized vehicle. You'll feel like a mechanic building it. You add motor, speed control, radio, servo, and battery.

5. R/C Superhero

Rcsuperhero.com $365

Complexity	4
Components	3
Documentation	3
Community	3
Completeness	3

This wild-looking R/C plane is life-sized (78" tall) and can take off vertically! The kit makes a superhero-shaped fuselage; you add R/C gear. Directions are clear, and the laser-cut parts go together smoothly, but it's a bit tricky – a fun and unique kit for experienced builders that will definitely command attention! 57" hero plans are just $10.

6. Align T-REX 450 Sport Super Combo

Align RC $500
rcplanet.com

Complexity	2
Components	5
Documentation	5
Community	4
Completeness	4

The Align T-REX 450 Sport is a terrific, well-supported copter that will satisfy trained beginners and advanced pilots. The Super Combo package includes all but the transmitter, receiver, batteries, and blade pitch gauge. The comprehensive manual advises that you rebuild the pre-assembled parts, checking alignment, using thread-locker on all screws and bolts, and lubricating where required.

The machined aluminum, carbon fiber, and plastic parts ensure a rigid, stable airframe capable of precise 3D aerobatics. The electronics (servos, speed control, brushless motor, and gyro) are perfectly suited to the copter, so most pilots won't want to upgrade. Simulator training or prior experience is highly recommended before flying.

7. Engel Submarine Type 212A

Alexander Engel KG $800
engel-modellbau.de

Complexity	2
Components	5
Documentation	4
Community	4
Completeness	4

The high-quality Engel Type 212 submarine kit is perfect if you're into scale models, history, and realism. Modeled after the German Navy's advanced Type 212 sub, this functional 1/70 scale model goes together smoothly using cast-resin, CNC'ed ABS plastic, brass, and stainless steel components. Engel's innovative Tech Rack mounting ensures that your electronics stay dry, and multiple electronic safeties make sure you don't lose your boat in the event of a mishap.

In the water, the sub looks incredible and dives, surfaces, and turns just like the real thing! Great for beginners and advanced hobbyists alike. Expect to finish it in a week or so (although the manual says it can be done in a weekend, which isn't likely).

MAKERBOT THING-O-MATIC KIT WITH STEPSTRUDER MK7

MakerBot Industries $1,299
makershed.com DSMB01

Complexity	4
Components	5
Documentation	4
Community	5
Completeness	5

If you want to get into 3D printing but don't know where to start, the MakerBot Thing-O-Matic Kit is the way to go. It's a complete kit, so you need no additional parts, and a large user community can back you up if problems pop up (not to mention Thingiverse, where you can find awesome open source designs). It took me about 20 hours to build the Thing-O-Matic and start printing, and I improved its accuracy with more tuning, calibrating, and tinkering with settings in the ReplicatorG software. If you have any trouble, read the discussion at the bottom of every build step. I've since 3D-printed many fun and handy things (everyone loves a 3D-printed gift!) and the MakerBot is now by far the most-used machine at MAKE Labs. —*Eric Chu*

The Phlatformer

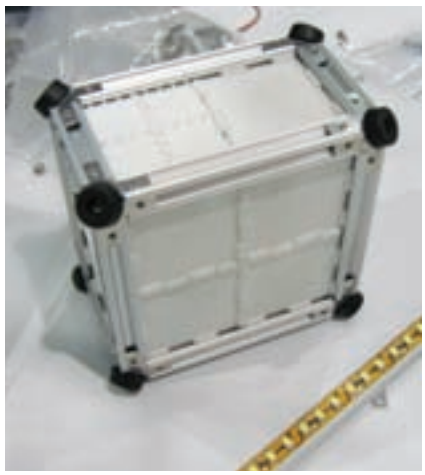
Phlatboyz, LLC $300
phlatboyz.com

Complexity	3
Components	5
Documentation	4
Community	3
Completeness	4

The Phlatformer is a hobby vacuum-forming machine that quick-melts 10" square plastic sheets into form-hugging shapes. Originally built for R/C modelers to make identical, lightweight body parts, it has many uses; for example, I plan to form custom holders to display my raygun collection. The kit's parts and thoughtful extras never skimp on quality, and include everything except a vacuum cleaner and a hot plate – I use a Rival S11P 11" skillet from Wal-Mart ($20). The DVD build guide can be supplemented with the active forum at phlatforum.com, and although there are lot of parts, most of them are self-indexing and more or less impossible to assemble incorrectly.

–*Sean Michael Ragan*

See the project build at:
makeprojects.com/project/t/1203



MICRORAX

Twintec, Inc. Starter Kit $80; Pro Kit $180
microrax.com

Complexity	5
Components	5
Documentation	N/A
Community	3
Completeness	5

Need miniature aluminum girders for your next robot? Look no further than the lightweight MicroRAX building system. Parts include 10mm aluminum beams and braces, plates, brackets, and other connectors. They've even developed adapter plates to attach your 'RAX to VEX and NXT constructs, allowing you to merge multiple building media. The beams are sold in 900mm lengths you can cut to size (precut lengths are also available), which is eminently sensible — forget pawing through a box of wrong-sized ones, and hack your own. You'll be surprised at what you can build: anything from mundane shelving to robots to computer enclosures. It even comes in ninja-black anodized aluminum! *—John Baichtal*

RoadTech H3 Toolkit

CruzTools, Inc. $83
cruztools.com

Complexity	4
Components	5
Documentation	N/A
Community	5
Completeness	5

Most hobbyists neglect to get the good basic pieces you need to work on everyday machinery like counterfeit printing presses, getaway cars, and the trap doors on elevator ceilings. Instead, they get the $20 all-in-one checkout-line kit featuring tools made from an alloy of sawdust, soda cans, and rat droppings. RoadTech H3 tools absolutely don't break; every tool in the roll is solid and dependable, from the combination wrenches to the flashlight to the lovely, jewel-like ¼-inch palm-sized ratchet. *—John Krewson*

CNC FUSION
MICHAEL & SHELLEY RODGERS

cncfusion.com

Machining high-quality conversion parts, CNC Fusion started in 2004 when Michael Rodgers, a machinist by trade, wanted to build a CNC machine but realized that he couldn't build the parts he'd designed for it without first owning … a CNC machine.

That initial desire led Michael to design and fabricate CNC conversion kits for small manual mills and lathes. The Rodgers' household garage has been converted into a shop where Michael machines the majority of the kit components using a huge five-axis CNC mill, while his wife, Shelley, runs the massive CNC lathe to machine the ends of the ball screw threads sold with their kits.

Popular around the globe – 40% of CNC Fusion production is shipped to overseas customers – Michael and Shelley are known for providing quality equipment and customer support second to none.

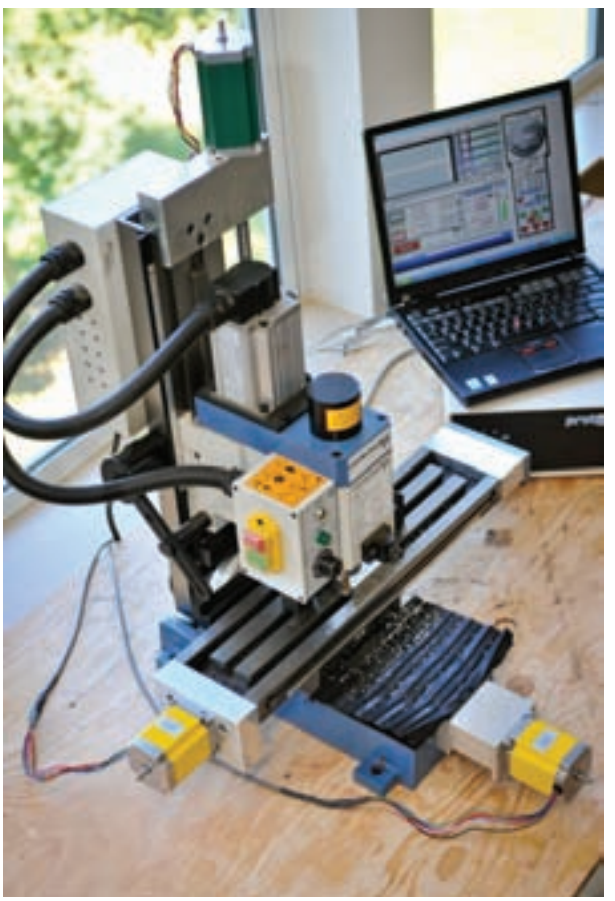
–Nick Raymond

X2 MINI MILL CNC KIT #2 WITH X-Y-Z BALLSCREWS

CNC Fusion $579 (as tested $696)
cncfusion.com

Complexity	3
Components	5
Documentation	3
Community	4
Completeness	4

What to do when you want to machine precise custom parts but don't have room or funds for a professional CNC? Invest in a manual mill that can convert into a CNC. Considered a great tool for the price, the X2 Mini Mill is the kit builder's top choice, and Probotix offers complete conversion kits (see below) to give it computer control. The platform has an active community, and the folks at CNC Fusion are known for great service (see profile on page 49). The conversion is straightforward and almost completely reversible, in case you decide to switch back — but why would you? *—Nick Raymond*



3-AXIS MONSTER MILL STEPPER MOTOR DRIVER KIT

Probotix $350 (as tested $624)
probotix.com

Complexity	4
Components	4
Documentation	5
Community	3
Completeness	4

Probotix offers several kits that add computer numeric control (CNC) to the X2 Mini Mill. I used their 3-Axis Monster Mill Stepper Motor Driver kit, plus a Ready-to-Run bundle that includes some additional components required to get it operational. For the computer itself, I used my old ThinkPad, but if your laptop is too new to have a parallel port, Probotix offers USB and PBX-RF breakout boards. Once the electronics are mounted and connected, you just need to install and configure CNC software, such as Mach3 or EMC2.

As a final step, you can fine-tune the machine and install limit switches and emergency buttons, which, although not included or required, are a safety feature that will inevitably prevent you from crashing your machine someday. Then, if you did everything correctly, you should be able to design and automatically mill your own precise and identical custom parts. *—NR*

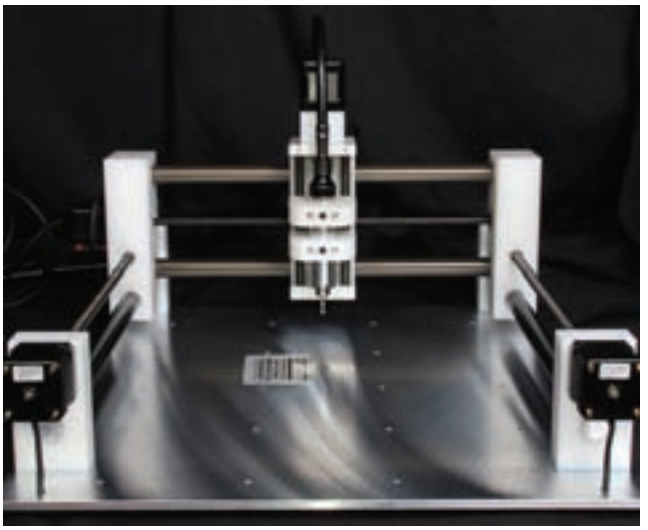
micRo-cnc kit

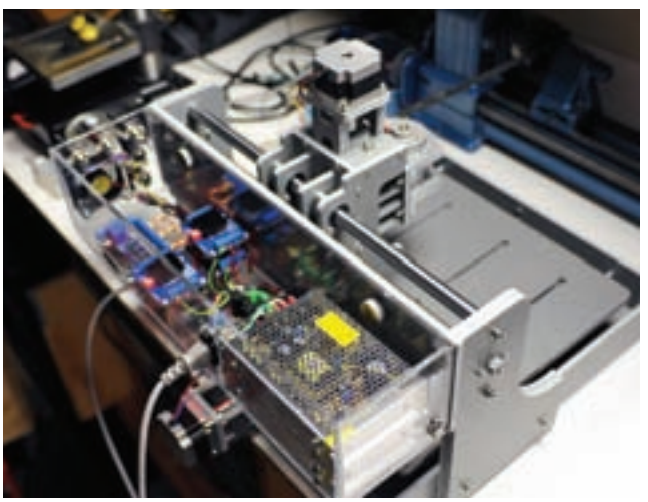
Lumenlab $699
lumenlab.com

Complexity	4
Components	5
Documentation	3
Community	4
Completeness	2

Despite all of the well-documented, homebuilt CNCs out there, I couldn't get the momentum to build one, so I decided to start with a kit. The micRo looks great (in a NASA sort of way), and with a working area of about 12"×10"×4", it's big enough to be useful to the hobbyist, small enough to be stowed under a workbench, and stout enough to cut aluminum and hard plastic. The only things I had to procure were the wiring and enclosure for the driver boards and an old PC, and the basic assembly offered almost no opportunities for mistakes. Documentation resides at lumenlab.com, and the companion forums are quite active. I've got some CAD learning to do before I can start making my own robot parts, but tinkering with this desktop CNC feels good, and I'm really glad I started with a kit.

–Steve Lodefink





ZEN TOOLWORKS CNC 12×12 COMPLETE PACKAGE

Zen Toolworks $1,082
zentoolworks.com

Complexity	4
Components	5
Documentation	5
Community	5
Completeness	5

This awesome three-axis CNC kit is a must-have for small projects such as circuit boards, engraving, or machining various small parts out of plastic or wood. Everything you need is included, except for a few hand tools, a vise, and a computer with a parallel port for running the software. The documentation contains clearly described steps alongside high-resolution photos, which makes the build process easy to follow. Zen Toolworks also has a large community backing their products, which is ideal for learning how to use a CNC machine, figuring out how to set up the software, or getting help with upgrades and attachments.

–Brian Melani

FIREBALL V90 CNC ROUTER KIT

Probotix $990 with additional 3-Axis ProboStep Motor/Driver Kit
probotix.com

Complexity	2
Components	5
Documentation	3
Community	4
Completeness depending on options	2-5

Although the V90 is an entry-level machine, it's decidedly not a toy. The way it functions is complicated – a platform carries the tool holder; a larger gantry moves the tool back and forth; the frame positions the gantry; and it's all driven by a motor turning the screw interposed between two shafts. Indeed, this three-axis Cartesian robot is probably the most complex machine I've ever built, and I had expected it to be correspondingly difficult to assemble; however, quite the contrary – it's easier than many common bike repairs. A thriving community actively updates the online build guide, and all the materials were very helpful during my own build. *–Sean Michael Ragan*

See the project build at:
makeprojects.com/project/p/1314

OUTDOOR & SPORT

Wood Surfboard Kits

Grain Surfboards $520 and up
grainsurfboards.com

Surf pioneer Tom Blake built the first hollow wood surfboards in the 1920s, but the technology was sidelined when polyurethane foam boards arrived mid-century. It's been revived in these beautiful boards from Grain Surfboards of Maine (*see MAKE Volume 21, page 40*). They're built like boats with a central spar, ribs, and decking. For the DIYer, Grain sells complete kits and also teaches classes, so bust out your spokeshave.

Greenlight Surfboard Supply of New Jersey has also gotten into the game, selling CNC-cut wood frames starting at $129; you'll have to head to the lumberyard to get the decking, but this looks like a cost-effective way to go.

–Keith Hammond

Surfboard Shaping Starter Kit

Greenlight Surfboard Supply $365 and up greenlightsurfsupply.com

Complexity	4
Components	4
Documentation	4
Community	2
Completeness	5

Traditional surfboards are fragile, plus they're made of toxic goo — polyurethane foam and polyester resin — that ends up as landfill. This deluxe starter kit has all the tools and materials you need to make a tougher, greener epoxy board using expanded polystyrene (EPS) foam that's recyclable. And Greenlight's lamination technique, using bamboo fabric instead of fiberglass cloth, is easier and safer.

The funky but comprehensive instructional videos show you the entire process — monkey-see, monkey-do — far better than a manual could. Greenlight provides a variety of board and fin templates to download and print, and they're generous with email advice on esoterica like fin placement.

You can shape a board in a weekend, but plan on a week or two to glass it. I learned a ton and ended up with the fastest board in my quiver.

—KH

See the build at: makeprojects.com/project/g/39

Sam Murphy (top)

DESIGNED FOR BUILDERS WHO DON'T HAVE A TON OF TOOLS.

MACKEY SQ2 SUPER CUB

Backcountry Super Cubs $54,725 supercub.com

Complexity	3
Components	5
Documentation	5
Community	3
Completeness	3

I chose this kit airplane because it has great performance, but even better, it's designed for builders who don't have a ton of tools. Only common hand tools are needed — no fiberglass work or welding. The fuselage comes pre-welded, and the wings fully assembled, so I only needed to assemble and wire the plane, add the engine and propeller, then cover and paint it. You can buy all components not in the kit (engine, instruments, radios, etc.) from supercub.com at open-market prices.

My assembly nearly complete, I can happily say the components, fit, and finish have not disappointed. My SQ2 has gone together smoothly and I can hardly wait to go flying.

—Mark Jaeger

KIT MAKER

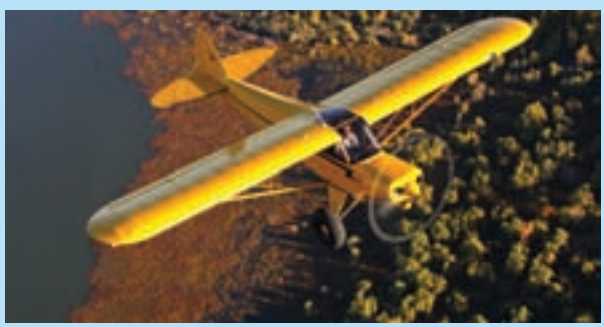
BACKCOUNTRY SUPER CUBS

supercub.com

Anyone who knows me well can tell you about my secret lust for Piper Cubs: bright yellow, fabric-covered, two-seater, tail-dragger airplanes from my youth, designed for low and slow flying with relatively few instruments and no computers. So when we began working on this issue, I immediately volunteered to cover my favorite fantasy kit of all time: the Super Cub Kit by Backcountry Super Cubs. When the youngest of my three kids graduates from college a few years down the road, this is what I'm saving up for.

Wayne Axelson, co-owner and general manager of Backcountry Super Cubs, took some time to talk homebuilt aircraft kits with me. First, as kits go, there's no getting around the fact that this one's expensive. From start to finish expect to pay somewhere around $100,000 to $110,000. But, as airplanes go, that's roughly half what you'd pay for a factory-built Super Cub replica. And if you were to sell it as a new homebuilt, you'd likely net $50,000 profit. That's if you didn't factor in your time. But hey, it's a labor of love, right?

Exactly how much labor and love can you expect to put into one of these? Axelson estimates about 800 to 1,000 hours. "If you're a really smart engineer, it'll take you longer," he says. "If you're a corn farmer from Iowa, you'll finish in a



lot less time." These kits are designed to be completed by the average person with no special skills, no welding or sophisticated machinery, nothing more than common hand tools. The biggest obstacle for some folks is that they overthink it and make it more complicated than it is.

Not surprisingly, Axelson said they consider documentation to be the most important part of their kits.

"Most of our customers have never built an aircraft kit before, and when they look at the unassembled kit, it can seem like a Space Shuttle," he says. "But when they get into it, they quickly begin to understand that it's actually easy and fairly straightforward."

And for support, the large and well-established Super Cub Club at supercub.org is an extremely active community of owners, builders, and kit makers who are quick to share tips and answer questions for fellow builders.

–Dan Woods

OUTDOOR & SPORT

MINIMA VEST

Thru-Hiker $53 and up thru-hiker.com

Complexity	4
Components	4
Documentation	4
Community	2
Completeness	4

Though making your own technical outdoor gear may seem out of reach, all it takes is a good pattern, solid instructions, techie fabrics, and some sewing skill. Thru-Hiker puts the pieces in your hands; you add the skill and patience. This vest kit is a good one to tackle for starters, and includes a toasty layer of Primaloft, Momentum90 premium ultralite ripstop outer layer, zipper, pull, and the flexibility to sew slim fit or regular.

—Goli Mohammadi

Where are the DIY outdoor gear kits? Paul Nanian started Thru-Hiker 11 years ago out of love for the community and an appreciation of how a well-designed kit teaches complex skills. He's nearly alone in this realm of kits. Why? "The economics of selling kits is not nearly as favorable as selling finished gear."

Pygmy Coho Kayak

Pygmy Boats $995 pygmyboats.com

Complexity	4
Components	4
Documentation	4
Community	2
Completeness	4

Using the book *Kayaks You Can Build* by Ted Moores and Greg Rossel, I built my first Coho, a stitch-and-glue plywood sea kayak. I considered kits from Redfish, Chesapeake Light Craft, Waters Dancing, and One Ocean, but I settled on Pygmy because other builders touted how accurate their CNC router-cut parts are. Plus I had seen a lot of Cohos out there over the years, which seemed to imply the design would be pretty well nailed down and refined by now. I was right.

The eight panels in the hull of the Coho make it a multi-chine boat, sort of halfway between a strip construction and a four-panel hull. I really like the way the deck fits elegantly onto the hull — no screws or nails through the deck. I also like the more modern vertical stern and the classic Greenland bow shape. The hull is not too wide, but very stable, and the deck's extra two panels create a shape that reduces the knocking of your knuckles when paddling.

The staff at Pygmy are very friendly and helpful, and the kit comes with a manual and all materials, including epoxy, fiberglass, and tape. I took a leisurely approach and spent 300 hours building it.

The Coho's response and performance are impeccable. The only problem is that six people a day will stop and ask you questions about it. It can actually delay your leaving the beach!

—Mark Forwalter

Reprinted from Cool Tools, kk.org/cooltools

VOILÉ SPLITBOARD KIT

Voilé USA $160 voile-usa.com

Complexity	3
Components	4
Documentation	2
Community	4
Completeness	4

This straightforward kit provides the parts to convert your snowboard into a backcountry splitboard capable of skinning deep into the wintry wonderland. All the heavy-duty hardware to mount the components to the board is included. You supply marine epoxy and the gumption to saw your trustworthy deck in half.

The process is simple but time-consuming, mostly in keeping tolerances tight and adding layers of epoxy since materials and connections need to be burly. The extra labor makes the rewards of slicing through an untracked powder stash in the glittering backcountry all the more earned.

—Damien Scogin

See the build at: makeprojects.com/project/b/70

WOOD DUCK 10 KAYAK

Chesapeake Light Craft $799 clcboats.com

Complexity	3
Components	4
Documentation	5
Community	4
Completeness	4

I've built several boat kits from Chesapeake Light Craft (CLC). I'd recommend the Wood Duck kayak with the okoume deck to start out with, but all of the kits have been very complete (just add sandpaper, paint, and varnish) and have gone together just as the straightforward, illustrated manuals say they should. In addition, there are two venues for problem solving: CLC phone support during business hours and the Builder's Forum on their site. There are a lot of seasoned builders there who love sharing their experiences.

—George Krewson

KIT MAKER

CHESAPEAKE LIGHT CRAFT JOHN HARRIS

clcboats.com

It wasn't long ago that a small boat built at home from a kit looked more like a floating sandbox than a boat. But this is rapidly changing. John Harris, owner of CLC, points to advanced panel-expansion software and accessible CNC machines as key factors. Harris says there's been more innovation in small boat building in the last five years than in the prior 13. Today's boat kits are easier to build, more sophisticated, and better performing. CNC machines also enable CLC to offer a broad selection of boat designs (over 84). When a customer orders a design, they effectively cut, pack, and ship a custom kit.

CLC's primary focus is helping first-time boat builders overcome the natural trepidation of building a kit boat. And Harris takes pride in their documentation, support, and online forums. "I think an open forum builds confidence with your customers – and they need confidence before they drop a grand on a boat kit and set aside weeks or months of their time."

–Dan Woods

CLOCKS

YOU MIGHT NOT WANT TO BRING THIS CLOCK TO THE TERMINAL.

Defusable Clock

Nootropic Design $35 nootropicdesign.com

This fully functional alarm clock lets you practice defusing simulated explosives. When the red button is pressed, the clock starts a scary countdown like bombs in Hollywood movies. There are four wires across the top of the clock, and you have ten seconds to choose the correct wire to cut. Programmed with the Arduino IDE, so hack away! Fake explosives not included. *—John Baichtal*

Complexity	3
Components	5
Documentation	5
Community	3
Completeness	4

Maker SHED

REAL TIME CLOCK KIT

Maker Shed $40 makershed.com JMBUN01

The Real Time Clock Kit Parts Bundle includes everything but the casing to build the PIC-based clock designed by Sparkle Labs and featured in MAKE Volume 09. Be sure to read the article for detailed explanations of how the PIC, Real Time Clock, and LED driver all work together to make a functioning clock. *–Marc de Vinck*

Complexity	3
Components	4
Documentation	4
Community	3
Completeness	3

MINTYTIME CLOCK

WickedDevice $23 makershed.com MKWD03

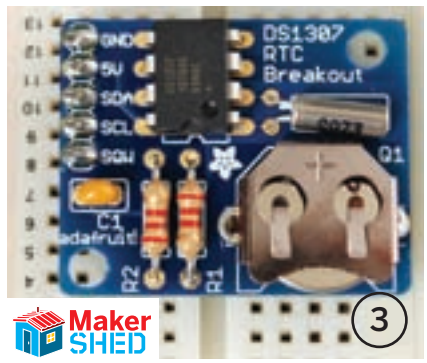
The MintyTime Clock Kit is a fun way to add a binary clock to almost any container. It's intended to be housed in a mint tin, such as the classic Altoids tin, but it looks great in almost any container, from a custom-designed, laser-cut enclosure to an old wooden recipe box. *–MdV*

Complexity	3
Components	3
Documentation	3
Community	2
Completeness	3

NEED TO ADD A CLOCK FUNCTION TO YOUR NEXT ARDUINO PROJECT?

1

2



3

ARDUINO-BASED

1. Chronulator PM2V

ShareBrained Technology $49
sharebrained.com/chronulator

Complexity	3
Components	4
Documentation	5
Community	3
Completeness	4

Alternative time-telling devices are compelling, but only if they're easy to read. Building a kit can be satisfying, but only if it leaves room for creativity. The Chronulator clock kit fits the bill on both counts. Solder it together, and you've got a microcontroller-based clock that converts time to current, displaying hours and minutes on two analog panel meters. Print out the supplied clock face templates, or customize the meters.

No housing is supplied, and this is where it gets interesting. I mounted my panels into a cigar box, and put the circuit board on top, its exposed wires lending to the retro-tech design. (I also considered using an old Mac G4 Cube case, or mounting it naked to the wall in a PanaVise.) Based on an Arduino-compatible Atmel ATmega168 chip, the Chronulator lets you download and modify the source code, connect to a computer via a USB-to-serial adapter, and display any kind of data. Would it be crass to have a "Number of People in My Facebook Friend Requests Purgatory" meter?

The Chronulator runs on a minimum of 1.8 volts and about 200 milliamps, so it'd be easy to power it from a small solar cell and a super capacitor. Then we'd have green time! *–John Edgar Park*

2. ArduiNIX ANX-1.0 Board

Robot Pirate $45
arduinix.com/main/store.htm

Complexity	4
Components	4
Documentation	4
Community	3
Completeness	3

Old-fashioned Nixie tubes are beautiful, but driving them in a circuit can be complicated since they often require voltages as high as 250V DC. The ArduiNIX board for Arduino makes it easy to add standard clock functions to your next project. Just be sure to design an enclosure that will keep those high voltages safe. I tested mine with various Nixie tubes I had in my studio, but I'm still looking for that perfect set to build the ultimate clock. *–MdV*

3. DS1307 Real Time Clock Breakout Board

Adafruit Industries $9
makershed.com MKAD19

Complexity	2
Components	4
Documentation	4
Community	4
Completeness	4

Need to add a clock function to your next Arduino project? This Real Time Clock (RTC) breakout board kit is your answer. Based on a DS1307 RTC and equipped with an onboard battery and crystal, this kit is simple to solder together, works well, and is easy to use thanks to Adafruit's online documentation. It's a great starting point for building your own clock, or even just time-stamping any data your project is gathering.

–MdV

CLOCKS

RETRO/VINTAGE

4. IN12 6 Tube Nixie Clock Kit

Peter J. Jensen, LLC $180
tubeclock.com

Complexity	3
Components	5
Documentation	5
Community	3
Completeness	5

Nixie tubes, beautiful relics of early computing, display their numerals with a quivery orange glow. Peter J. Jensen makes Nixie tube clock kits, and it was a joy to put one of them together, thanks to the clear step-by-step instructions and parts envelopes labeled with corresponding numbers.

Jensen designed the clock and circuit board himself, and his elegant sense of aesthetics became apparent to me as I assembled the board and mounted it and the tubes into the handsome metal case. The finished clock looks like the creation of some famous mid-century modern designer. I plan to buy more of Jensen's clock kits to make and give as gifts.

–Mark Frauenfelder

5. Edo-Style Clock

Gakken $50
makershed.com MKGK29

Complexity	3
Components	5
Documentation	4
Community	2
Completeness	4

I had a great time building the Edo-Style clock kit from Gakken, and was amazed at its accuracy over several months of use. The kit is well designed, durable, and fun. The included picture-based directions are easy to follow, even if you don't know Japanese, but if you plan to make one, you can also refer to my step-by-step tutorial for tips and tricks I learned during my build. *–MdV*

See the project build at:
makeprojects.com/project/b/485

6. Ice Tube Clock

Make: MAKER MADE

Adafruit Industries $85
makershed.com MKAD16

Complexity	4
Components	4
Documentation	5
Community	4
Completeness	5

The heart of the Ice Tube Clock is a distinctive, vintage, Russian vacuum fluorescent display (VFD) housed in a transparent, laser-cut enclosure. The clock features a precision watch crystal, alarm function, and battery backup. The build quality and online instructions are excellent, as is the completeness of the kit. Anyone who stops by my studio is always impressed with the VFD display, and the conversation usually steers towards reminiscing about old radios and VCRs from the 70s and 80s that used similar displays, albeit in not-so-similar laser-cut enclosures. *–MdV*

7. Monochron Clock

Make: MAKER MADE

Adafruit Industries $80
makershed.com MKAD17

Complexity	4
Components	4
Documentation	5
Community	4
Completeness	5

The Monochron is an extremely rewarding kit to build. Not only is it fun, but the finished clock adds retro flair to any home. As with all Adafruit kits, the instructions are clear and well thought out. The clock features an alarm function, custom laser-cut case, and several different display modes to suit your mood or decor. It's completely open source, and free-download variations of the software display the time using a simple modern font, Dali-esque animations, or retro arcade numerals. Feeling more adventurous? Program your own custom clock functions and fonts. Just don't forget to share your code! *–MdV*

See the project build at:
makeprojects.com/project/a/491

LED CLOCKS

8. Solder: Time

Make: MAKER MADE

Spikenzie Labs $35
makershed.com MKSKL12

Complexity	2
Components	4
Documentation	4
Community	2
Completeness	5

Solder: Time was a perfect father-daughter project: my 8-year-old assembled the components and I soldered. Afterwards, she had a chunky blue wristwatch that her cousin admired longingly, so we made another one for her. Now their friends are asking for them. I think we've started a trend! *–MF*

9. Wise Clock 3

Wise Time With Arduino $62
timewitharduino.blogspot.com

Complexity	2
Components	4
Documentation	3
Community	2
Completeness	2

The Wise Clock 3 is an easy and highly customizable driver for a 32×16 RGB LED matrix display (included). Its default program includes several different clock modes, but it can also display the date and temperature, or any message. Check out all the different clock faces, including Pong and Pac-Man. *–MdV*

10. Bulbdial Clock

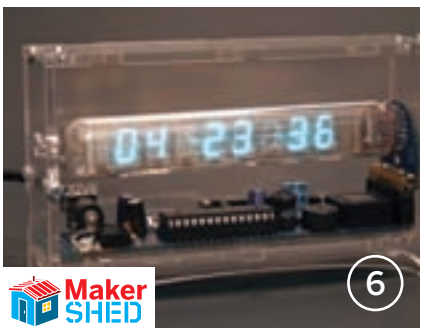
Make: MAKER MADE

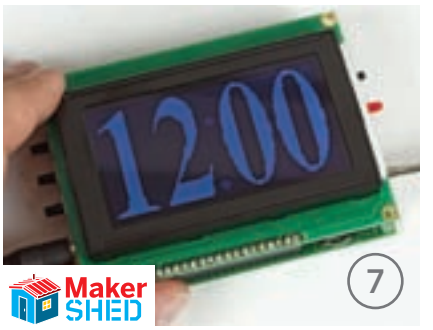
Evil Mad Scientist Laboratories $90
makershed.com MKEMS8

Complexity	4
Components	4
Documentation	5
Community	4
Completeness	4

The Bulbdial Clock displays analog time, without any motor, movement, or screen. The 72 LEDs cast shadow hands across its face, with red, green, and blue for hours, minutes, and seconds. It's a beautiful effect, and the kit is not difficult to assemble, thanks to incredibly well-done instructions. *–MdV*

THE FINISHED CLOCK LOOKS LIKE THE CREATION OF SOME FAMOUS MID-CENTURY MODERN DESIGNER.





Andrew Harrow (1); Marc de Vinck (4, 9, 10)

KIT MAKER

SPIKENZIE LABS
MARK DEMERS

spikenzielabs.com

Mark Demers is no newcomer to the culture of makers; he was raised by them, including his father, mother, brothers, uncles, grandparents, babysitter, you get the picture. Always the entrepreneur, in his teenage years, he built a silk-screening setup and sold custom shirts to local teams and clubs. Combining his maker sense and his business sense led to the logical next step of starting his kit business, Spikenzie Labs.

Demers strives to make kits that not only look good, but work well, always imagining how people will interact with them and where folks may run into snags. "A good kit is one that is designed properly, works well when built, and does something that the person building the kits wants or needs it to do." Demers takes pride in his work, down to tracing the circuit boards by hand, choosing the best parts, and providing superior instructions and photos.

–Goli Mohammadi

HOME & SHELTER

Fun kits for the backyard and living room.

SHELTER

1. YurtDome Kits

Shelter Systems $518 and up
shelter-systems.com

Complexity	2
Components	5
Documentation	3
Community	4
Completeness	5

I've thought of building a dome for years, and when I was looking for a quick and relatively inexpensive place to put my workshop for the winter, this kit from Shelter Systems seemed like just the ticket. Based in Santa Cruz, Calif., Shelter Systems is still using the same non-puncturing "grip clip" technology they used in the 80s to make mod-friendly yurt-dome hybrid structures (panels are shingled together and easily replaceable).

These things are adaptable for snow and woodstoves, and they're great for greenhouses (they also come with translucent panels). The tent was surprisingly easy and fun to set up (we actually had to fight off volunteers who wanted to help), and we got it standing in about 30 minutes. Let it rain!

–Meara O'Reilly

2. Eskimold Igloo Building Kit

Tundra North Manufacturing $24
webstore.eskimold.com

Complexity	1
Components	4
Documentation	2
Community	1
Completeness	5

This is loads of fun – a way to get the kids out of the house during the winter, or make a cheap little ice fishing house that's disposable.

Any type of snow can be compacted into this nifty device to quickly create hundreds of perfectly formed, slanted, stackable igloo building blocks. The Eskimold differs from other snow block kits in that one block edge is concave, the other is convex, allowing them to fit together end to end. The blocks also curve inward slightly (picture an igloo's interior walls). The last block on each row has to be trimmed, since the igloo gradually leans in as it's built, and the diameter shrinks with each row. The included plastic snow saw works well.

A skilled builder could mimic the traditional hemisphere igloo design, while the casual builder will end up with a taller, pointier beehive design, which you can actually stand up in. You can make the blocks in advance, let them freeze overnight on a scrap of plywood, stack them on a sled, then haul them to your building spot.

My teenage son slept in his own igloo creation one night, and was comfortable in -15°F weather. If you have a couple of kids, get two Eskimolds to avoid fighting. These plastic buckets are durable, and will last for years.

–Dean Knudson

Reprinted from Cool Tools, kk.org/cooltools

HOME

3. SunMod Remote Kit

Sparkle Labs $18
makershed.com MKSL03

Complexity	1
Components	3
Documentation	4
Community	3
Completeness	3

In MAKE Volume 25, Sparkle Labs showed how to hack your TV remote control to make it solar powered. Just add a tiny solar panel and rechargeable batteries. It works with any AA- or AAA-powered remote.

See the project build at: makeprojects.com/project/s/969.

Now they've put together this easy kit: a flexible 4.8V solar cell with soldered leads and connector pads, and double-sided tape. NiMH batteries not included.

–KH

4. Chofu Wood-Fired Hot Tub

Island Hot Tub Company $863
islandhottub.com

Complexity	2
Components	5
Documentation	5
Community	5
Completeness	4

The Chofu is a very simple, and very beautiful, DIY wood-fired hot tub heater. It looks like a potbellied stove with an Eastern aesthetic, and it comes from Japan. Any container that'll hold water can be the hot tub (metal stock tanks are a great choice). The stove is connected to the tub by two openings. The lower opening allows cold water to fill the stainless steel water jacket that makes up the Chofu's round sides and top. As the water is heated by the fire, hot water rises to the top and pours out the upper opening into the tub, and colder water from the tank is drawn back in. This is the power of a thermo-siphon; no pump is needed. The Chofu naturally circulates the water, letting you have a hot soak completely off-grid.

We got our Chofu in the mail, and setting it up was easy; the hardest part is connecting the stovepipe parts together. It can all be done in under an hour. Stoke the fire every 45 minutes, stir the water too, and in 4 hours, a 250-gallon tank will be close to 104°F.

The Chofu setup is very open to mods: employ a lid to keep your tub cleaner, longer, without the use of chemicals, or insulate the tub to increase efficiency. It also appeals to the budget-minded.

While the stove ($863 plus shipping) and tank ($200 locally) will certainly set you back, it's a fraction of the cost of a new manufactured hot tub, and it'll never cost you a penny in electricity. It's a must for the modern homestead.

–Brookelynn Morris

MORE FUN HOME KITS

5. ElectroPUFF Craft Lamp Dimmer Kit

International Fashion Machines $30
ifmachines.com

Complexity	2
Components	4
Documentation	4
Community	2
Completeness	5

This soft, whimsical pompom connects to any incandescent lamp and controls light levels with just a gentle tap. IFM's patented electronic textiles are the magic behind it. Conductive yarns that sense your touch are combined with recycled carpet fibers to form the soft switch. This kit appeals to kids, grandmas, science geeks – anyone who enjoys crafts or technology.

–Arwen O'Reilly Griffith

6. Fire Pit Kit

Make: MAKER MADE

Jon Sarriugarte $95 and up
formandreform.com

Complexity	2
Components	4
Documentation	4
Community	2
Completeness	4

Blacksmith/sculptor Jon Sarriugarte of Form & Reform makes magical propane-powered fire pits. As he puts it, "Not only do they give off warmth but you can entertain your guest with drawings in the sand that burn where you draw!"

You can buy one ready-made, or pick up one of his fire pit kits to make your own.

–AOG

7. PumLantern Kit

Maker Shed $30
makershed.com MKSB009

Complexity	3
Components	3
Documentation	4
Community	2
Completeness	4

This kit includes everything needed to build a solar-charged, nighttime-activated, light-pulsing lamp. It charges all day from the SCC3733 solar cell, and "pumms" the four ultra-mega-super-bright LEDs to cast artistic silhouettes against the walls of the stylized cardboard lantern.

The LEDs are a random grab of white, blue, red, orange, and green. Basic soldering is needed to assemble the Pummer circuit, while the laser-cut lantern slides and snaps together with little effort.

Brookelynn Morris (4)

SCIENCE

Experiment! Re-create great inquiries in neuroscience, genetics, space, communication, and other fields – or test out hypotheses of your own.

1. SpikerBox

Backyard Brains $100
backyardbrains.com

Complexity	3
Components	5
Documentation	5
Community	5
Completeness	5

This is a solder-together kit for studying the electrical impulses of cockroach neurons. The online instructions are excellent, with videos and plenty of clear photos of the assembly process. My 8-year-old daughter identified and inserted all the electrical components into the clearly marked printed circuit board through-holes, and I did the soldering. She asked me about the function of resistors, capacitors, timer chips, etc., and I felt she got a lot out of the activity.

But when it came time to pull a leg off one of the cockroaches ($10 for a set of three *Blaberus discoidalis*) and insert electrodes into it, my daughter objected. She had already named the bugs and enjoyed feeding them apple slices and petting their backs with her finger. I told her that the instructions indicated that cockroaches' legs grow back, but she put her foot down. Now we have three pets and a gadget that produces Geiger-counter-like sounds when you touch the electrodes to your fingertips.

–Mark Frauenfelder

2. TubeSat Personal Satellite

Interorbital Systems $8,000
interorbital.com

Complexity	5
Components	4
Documentation	3
Community	5
Completeness	3

TubeSat makes space your personal laboratory. You build a satellite the size of a large soup can, get it launched into a 310km Earth orbit moving 17,000 miles an hour, and talk to it via ham radio a few times a day for 1–3 months. Smile as you reflect on your new skills in surface-mount soldering, amateur radio (you'll need a license), spacecraft control, solar power, and, yes, rocket science.

Even with a kit, building a satellite requires significant time and skill-building. You'll need to order (or make) two-layer PCBs, and master reflow soldering to attach the fragile solar cells. But the manual is clear, you don't need much math or science, and an online community shares techniques. I'm adding an ion engine to my TubeSat, which brings high-voltage electronics, micro-machining, and calculus into the mix.

The kit and launch cost $8,000 for academics and citizen scientists. (A larger CubeSat kit is $19,125, and Arduino versions of both are in development.) Success isn't guaranteed – rockets fail, space radiation breaks electronics, and launch stresses can shake a satellite apart. (Test yours in a near-space balloon first.)

My TubeSat launches in spring 2012, and one thing's for sure: when it's all done, and the satellite burns up, I'll never look at a shooting star the same way again.

–Wesley Faler

3. Perfume Science

Thames & Kosmos $60
thamesandkosmos.com

Complexity	3
Components	4
Documentation	4
Community	1
Completeness	3

Learn about the sense of smell with eight perfume oils and a variety of jars, mixers, and pipettes. Experiments range from fragrance extraction to composing your own perfume scents. My friend and I enjoyed one experiment where we prepared test strips of all the fragrances and then guessed which we were sniffing. I got two wrong and he missed five (Lemony and Mentha are freebies, since they're unmistakable).

Reading the manual is a must – it's well-written, with lots of fun scientific facts and historical anecdotes. I learned about human olfaction, the history and art of perfume composition, and how scents are analyzed and categorized. Thanks to this kit, I'm now armed with an understanding of the Fragrance Family Tree: floral, green, animal, and spicy/woody.

–Laura Cochrane

4. Energy Wiz

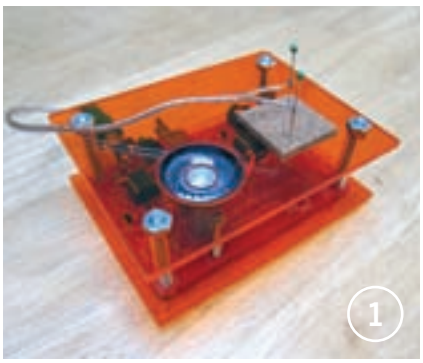
ScienceWiz $20
sciencewiz.com

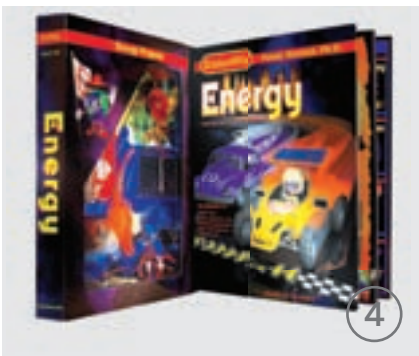
Complexity	2
Components	3
Documentation	5
Community	3
Completeness	4

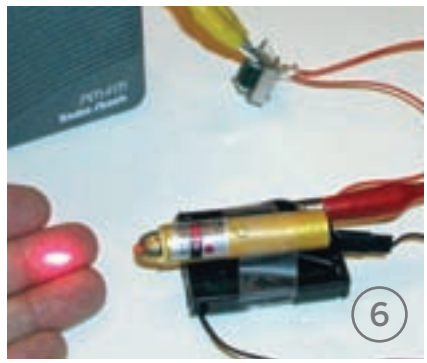
Aimed at kids 8 and up, this kit has real heart. Its 48-page workbook and components (solar cell, buzzer, two motors, LED, capacitor, copper rivets, pinwheel, etc.) take you through lessons and fun experiments that teach the basics: What is energy, as distinct from force? What forms does it take? How can it be converted between forms?

My daughter and I had fun making the solar-powered fan, electric car, and other projects. She's a bit young for the kit, so as she used various bits to decorate a finish line for the solar car, I experimented with what else I could power, and for how long, with the 6-farad supercapacitor – those things are amazing. One recommendation: add your own alligator clips (without the leads) to make the solderless joints less tweaky.

–Paul Spinrad







5. Cloning a Fluorescent Gene

Genotyp $600
speakscience.org

Complexity	5
Components	5
Documentation	3
Community	5
Completeness	5

When I told my 8-year-old daughter I had a kit to clone fluorescent jellyfish DNA, she was excited to try it. But this is a high-school level project. The reagents are sent in a styrofoam box with dry ice, and the projects require a polymerase chain reaction thermal cycler (which Genotyp will loan out to classrooms that don't have one). It's complicated (I scratched my head at some of the manual), but looks to be an affordable science kit for older students and classrooms. *–MF*

6. Laser Voice Transmitter and Receiver

Scitoys $25 and $7
scitoyscatalog.com

Complexity	2
Components	4
Documentation	3
Community	2
Completeness	4

This amazing demo shows how you can transmit sound over a laser beam. The transmitter modulates power to a laser pointer with audio from a headphone jack. The receiver is just an earphone and a solar cell; no power source. I assembled both in minutes, and it was strange (in a good way) to hear music whenever I held the cell in the beam. As seen in MAKE Volume 16, the Spy Tech issue! *–PS*

7. Litiholo Hologram Kit

Litiholo $100
litiholo.com

Complexity	2
Components	4
Documentation	4
Community	1
Completeness	5

Making holograms became faster and easier a few years ago when Litiholo introduced its Instant Hologram film. Like old Polaroids, these film plates require no developing after exposure, which means, in about an hour, you can make your own transmission hologram of anything that will sit still next to the plate. The kit also includes an LED darkroom light and the SafetyLight Laser Diode that you use to both make the exposure and view (or "reconstruct") the hologram.

–Arwen O'Reilly Griffith

8. Analog Geiger Counter

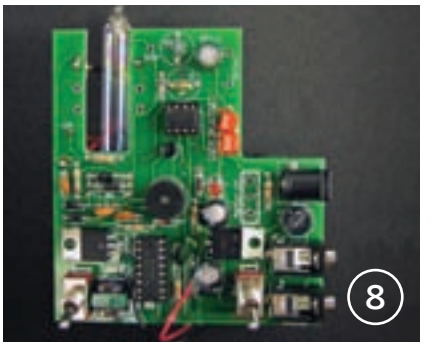
Images Scientific Instruments $139
imagesco.com

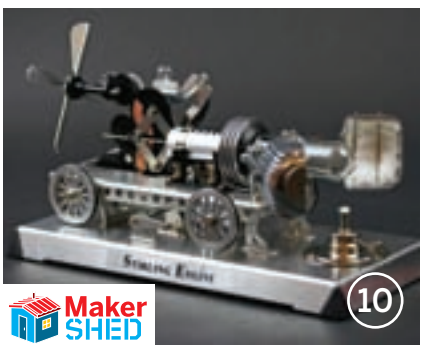
Complexity	3
Components	5
Documentation	3
Community	3
Completeness	4

MAKE contributor John Iovine has been designing and improving affordable Geiger counters for decades. After Japan's nuclear crisis last spring, his company was swamped with orders. Now they're working on even better designs and DIY kits.

This analog counter detects beta radiation above 36 kilo-electron volts (keV) and gamma above 7keV, signaling each radioactive particle detected with an LED flash and a click in the headphones. For digital output, logging, and graphing, add the DMAD-03 digital meter adapter kit ($60). *–PS*

SCIENCE





GREAT KITS FROM THE MAKER SHED

9. Reinventing Edison: Light Bulb Kit

Harris Educational $60
makershed.com MKHE01

Complexity	2
Components	5
Documentation	5
Community	2
Completeness	4

Thomas Edison purportedly said that he didn't fail 700 times in trying to make the incandescent light, he succeeded in proving 700 ways not to do it. Now it can be your turn. This fun science kit is designed to excite and engage experimenters of all ages in re-creating the development of the first light bulb. Build your own working Edison bulb using the included safety vacuum chamber and a number of different filament materials, including carbon and tungsten.

10. Stirling Engine

Gakken $130
makershed.com MKGK5

Complexity	5
Components	4
Documentation	3
Community	2
Completeness	5

This beautiful engine teaches you the basics of thermodynamics as its power comes from an external heat source, which can be anything from fuel to solar to geothermal energy. The instructions are in Japanese, but the Maker Shed page has an English translation. MAKE is proud to be the exclusive distributor in North America for this kit, part of Gakken's Sophisticated Science Kit for Adults series.

11. Brain Machine

Make: MAKER MADE

Adafruit Industries $35
makershed.com MSBM

Complexity	3
Components	4
Documentation	5
Community	5
Completeness	5

Hack your brain! Put on these glasses and headphones, close your eyes, and enjoy some harmless hallucinations as you drift into deep meditation. You'll come out after the 14-minute program feeling fabulous. Sound and Light Machines (SLMs) help people sleep, wake up, meditate, and more. They work by generating light pulses (seen through closed eyelids) and sounds at brain wave frequencies.

With this kit, you'll build an SLM for much cheaper than you can buy one. As seen in MAKE Volume 10.

12. The Truth Meter

Maker Shed $25
makershed.com MSGR01

Complexity	2
Components	3
Documentation	4
Community	2
Completeness	4

See what happens when someone asks you questions or when you laugh or get surprised. Everyone responds differently. See if you can turn the LED on with your mind. Try it on your friends or adversaries – it's a great way to get to know someone! We've even included a few extra resistors, so you can calibrate the circuit and experiment with different sensitivities or hack it to get GSR data into your Arduino. Fun!

See the build at:
makeprojects.com/project/t/703

Cody Pickens (12)

TOYS & GAMES

The Dice Kit

Spikenzie Labs $20 makershed.com MKSKL09

Make: MAKER MADE

Complexity	2
Components	5
Documentation	5
Community	2
Completeness	5

This is a fantastic introductory electronics kit that comes with your choice of large red or green LEDs and everything else needed (aside from a soldering iron, solder, and flush cutters) to make one electronic 6-sided die. (The manufacturer says: "The name Dice Kit sounds a great deal better than 'Die Kit', so we bent English grammar rules just a little in the name of making a marketable product." Good move!)

The finished project is fun to use: you lift it a half-inch above the table and drop it to "roll" the die. A piezo-electric buzzer senses the impact and triggers the circuit to generate a random number and illuminate the LEDs. Everyone I show it to smiles at the way it works.

—Mark Frauenfelder

GRYPHON ORNITHOPTER

BirdKit.com $10

Complexity	2
Components	4
Documentation	4
Community	3
Completeness	4

At MAKE Labs we built a squadron of balsa-and-tissue ornithopters for William Gurstelle's how-to article in MAKE Volume 08. The trickiest part was bending the tiny wire crank that flaps the wings in time. Even with Bill's clear instructions, that little wire was trial-and-error.

This kit spares you that error. The pre-bent crank and laser-cut parts fit precisely; you only need scissors, glue, and a few evenings. Instructions are well illustrated, and online there's a build video and a teacher's guide. The delicate 'thopter weighs ¼oz, has a 16" wingspan, and flies about 1 minute on 200 turns of the rubber band. At press time BirdKit.com was upgrading the kit, so yours may fly that much better.

–Keith Hammond

ELECTRIC PLANE LAUNCHER

4M Industrial Development $20 4m-ind.com

Complexity	2
Components	3
Documentation	3
Community	1
Completeness	5

This kit's great for office warfare but it's really meant for flight-testing paper airplanes. Two DC motors spin rubber discs in opposite directions to grab your plane and propel it up to 30mph. There's no soldering, just pre-cut wires and a screw terminal block.

Intended for teaching kids ages 14 and up, it's easily assembled in minutes with a screwdriver (included); you add only batteries. I'd say kids 10 and up could build it, with adult help to push the motors tightly into grommets. Caveats: the instructions have some inconsistent drawings (the online video helps), and the front leg is fastened by a nut on the deck directly in the plane's path – a dubious placement, though it hasn't tripped up my planes yet. (Incoming, Jake!)

–KH

TOYS & GAMES

Maker SHED

Pendulum Challenge

Maker Shed $26
makershed.com MSPC01

Complexity	2
Components	4
Documentation	4
Community	3
Completeness	5

How are your reflexes? Ken Delahoussaye's Pendulum Challenge (featured in MAKE Volume 26) is a fun and clever handheld game that you assemble on a printed circuit board. The game's arc-shaped array of 15 LEDs (14 red and 1 green) simulate the path of a swinging pendulum, which you try to stop at the bottom of its arc through 5 levels of difficulty. A piezo buzzer adds sound effects (which the mode button can silence for the benefit of hard-working parents and studious siblings).

SOLAR GRASSHOPPER KIT

OWI, Inc. $12
makershed.com MKOW02

Complexity	1
Components	4
Documentation	4
Community	1
Completeness	5

Build your own life-size grasshopper and explore solar power with this educational mini solar robot kit. The snap-together, attention-getting Solar Frightened Grasshopper teaches how solar energy can be used to generate electricity.

This easy-to-use science kit is perfect for first-time experimenters with little or no experience. Ages 10 and up.

VIDEO GAME SHIELD

Wayne & Layne $23
makershed.com MKWL02

Complexity	4
Components	4
Documentation	4
Community	4
Completeness	4

The Video Game Shield is an Arduino add-on shield to make your own video games, including graphics, text, sound effects, and music!

Using the power of open source, this shield allows you to make awesome black-and-white video games on your TV. It supports up to two Nintendo Wii Nunchuk controllers for an easy and familiar interface. (Arduino and Wii Nunchuks not included.)

KARAKURI SOMERSAULT DOLL

Gakken $75
makershed.com MKGK26

Complexity	2
Components	3
Documentation	4
Community	1
Completeness	5

Employing a centuries-old secret technique from the Edo period, this kit has everything needed to create an acrobatic doll, plus a festive kimono and a tiered pedestal on which to perform. You can even adjust the velocity of the doll's action. The instructions are in Japanese with beautiful illustrations that make it easy to put together.

See the build at:
makeprojects.com/project/k/42

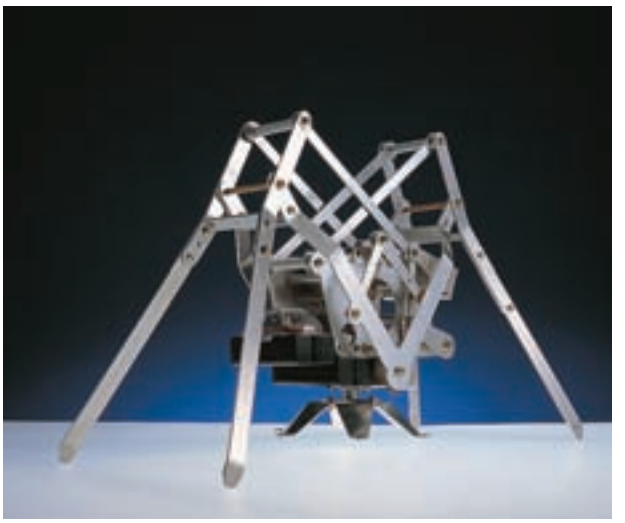
MECHAMO INCHWORM

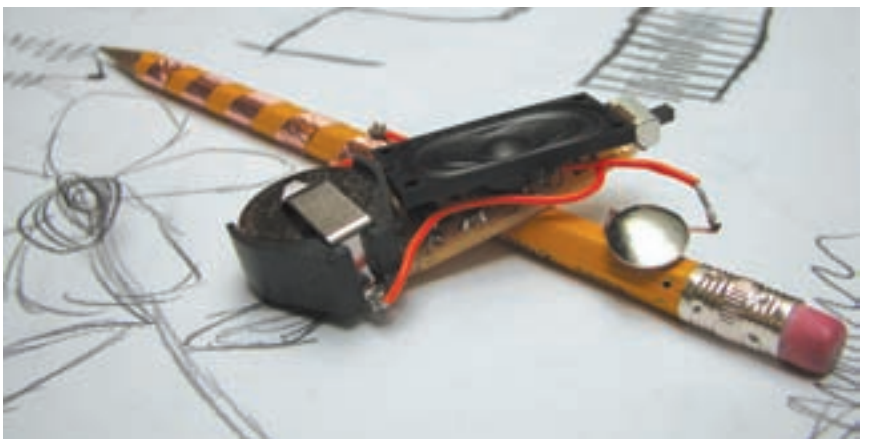
Gakken $70 makershed.com MKGK3

Complexity	3
Components	5
Documentation	4
Community	3
Completeness	4

Make a mind-blowing remote controlled "Meka-Inchworm" robot with this fun, no-soldering-required kit. You've got to love a machine that moves like a bug! It's Japanese, but we've got English instructions at makezine.com/go/inchworm. MAKE is proud to be the exclusive distributor in North America for these brilliant kits, part of Gakken's Mechanical Animals Series.

Reviewer Tyler Bennett of Cary, N.C., writes: "This kit was a lot of fun for me as well as my 11- and 12-year-old grandkids. The kids put the kit together (with me looking over their shoulders) in around two hours and then we all enjoyed running it around on the floor."





Drawdio

Adafruit Industries $20 makershed.com MKAD12

Make: MAKER MADE

Complexity	2
Components	4
Documentation	4
Community	4
Completeness	4

Drawdio is an electronic pencil that lets you make music while you draw. It's a great project for beginners: an easy kit with instant gratification. Invented by Jay Silver, it's a very simple musical synthesizer that uses the conductive properties of pencil graphite to create sounds. The result is a fun toy that lets you draw "musical instruments" on any piece of paper.

The kit comes with all electronic components, PCB, hardware, and a 2B pencil. It works with any pencil (the softer, the better), and is ridiculously fun for all ages. Reviewer Sue from Boston writes: "I have never soldered anything until this kit. It took about an hour to put together, going slow. Once I finished and tested it out, the shrill sound it produces made my cat hiss at me and run out of the room. I'd recommend this to any beginners out there."

Reviewer Barry from Emeryville, Calif., writes: "I built a Drawdio and showed it around my physics class (which happens to be studying electrical circuits) and got a great response. One of my guys even started brainstorming a musical instrument, something really big and loud based on the resistance of a long copper pipe. Good times!"

SIMON

SparkFun Electronics $25

makershed.com MKSF7

Complexity	2
Components	4
Documentation	4
Community	3
Completeness	5

All components are through-hole, making this Simon kit great for beginners.

Reviewer Thomas O'Brien from San Antonio writes: "The instruction booklet is very well written and goes step by step with clear explanations. My grandson Ben, 5, helped put components in the holes of the circuit board, then I soldered them, and he clipped the wires. He likes working with the magnifier to see what's going on, while I solder. I showed him how to insert batteries correctly (look for the plus sign). The kit went together without a hitch and worked the first time. Grandma, look what we made! Thanks for a nice, well-designed kit – an easy one that a youngster can help build."

CRAFT

BY BROOKELYNN MORRIS,
CRAFT STAFF WRITER

UNUSUAL & FUN

ORDER A CUSTOM KIT FROM YOUR OWN PHOTO.

PEE-WEE HERMAN PAINT BY NUMBER

PopParty $35 popparty.etsy.com

Complexity	4
Components	5
Documentation	5
Community	1
Completeness	5

Without ever painting a portrait before in my life, I re-created the likeness of Pee-wee Herman with this PopParty Paint by Number Kit. Choose from the Golden Girls, Pee-wee, or my personal favorite, Lindsay Lohan's mug shot. Better yet, order a custom kit from your own photo for $125, with up to 16 acrylic paint colors.

The project required as much focus as I could muster (while watching bad TV!) and a very steady hand, but my painting looks exactly like the printed version. Or should I say, exactly like the real Pee-wee.

LEGO SYRINGE KIT

Sean Ragan $20 seanmragan.etsy.com

Complexity	2
Components	5
Documentation	5
Community	2
Completeness	5

MAKE blogger Sean Ragan created this provocative kit enabling you to make a medical replica out of nothing but Lego, with the exception of one slightly modified piece. Build the syringe by following the easy "order-of-operations," using red for blood, or maybe a blue medicine from the future, or create yourself a sickly yellow-green poison. Complete your work of art with a single drop of Lego, seemingly pouring out the end of the needle.

REMAKE IT PLASTIC BAG TRASH CAN

RePlayGround $17 replayground.com

Complexity	2
Components	5
Documentation	5
Community	5
Completeness	4

Turn your trash into treasure, or in this case, a trash can. Out of the box, this metal basket skeleton won't hold a lot, but add your own recycled material, and it becomes much more useful. Walls are formed by weaving through the spokes. If you like paper crafts, weave in folded strips of newspaper. If you're into sewing, use fabric scraps. If you're into irony, make your garbage can out of garbage bags!

Nat Wilson-Heckathorn

THE HARDEST PART IS WAITING FOR THE GLUE TO DRY.

Schacht Mini Loom Weaving Kit

Schacht Spindle Co. $35 halcyonyarn.com/kidstuff.html

Complexity	3
Components	5
Documentation	4
Community	1
Completeness	5

Beginners can learn how to weave their own bags, mats, coasters, and more with this portable weaving kit. The plastic mini loom comes with two shuttles, a beater, a weaving needle, five colors of yarn, and project instructions. Perfect for kids! *—Natalie Zee Drieu*

MAKE YOUR OWN CAT PUPPET

Folkmanis Puppets $14
makezine.com/go/handpuppets

Complexity	2
Components	5
Documentation	4
Community	3
Completeness	4

Starting with the basic sock-style, this kit empowers kids to create handsome puppets and teaches different construction methods. With simple instructions, pre-marked patterns, pre-sewn parts to stuff, and packaging that becomes a stage, this kit is only two hours from coming to life. The hardest part is waiting for the glue to dry, but that's the perfect time to color the stage. The finished puppets are adorable, and it's my new favorite gift for young kids in the family, particularly if I live close enough to help them put on a show. *—Gregory Hayes*

Pottery Kick Wheel Wood and Metal Parts Kits

Brent $551 (for both kits)
amaco.com

Complexity	3
Components	5
Documentation	4
Community	4
Completeness	5

A friend and I tried to build a pottery kick wheel ourselves, but the concrete flywheel we poured cracked immediately, rendering the wheel a bit wobbly. Fortunately I later discovered these two kits, which include everything you need to make a solid kick wheel, including the wheel head, ball bearings, and all the pre-cut wood. And if you're a better woodworker than me, you can just buy the metal kit and build the wood frame yourself. I use it all the time to make pottery, which is what it's all about!

–Steve McDonald

Adapted from pottery-on-the-wheel.com.

CRAFT

NEEDLEWORK

OCTOPUS FRIEND

Hi-Fiber Kits $18 hifiberkits.com

If you've never needle felted before, you'll start this kit a beginner, and complete it an expert. With enough wool to make two large friends, or a handful of tiny octopi, these creatures will take shape before your eyes, and as you work, you'll refine your skills. Follow the clear and funny directions to needle the wool into a three-dimensional, eight-tentacled, fuzzy cephalopod. *—Brookelynn Morris*

Complexity	3
Components	5
Documentation	5
Community	4
Completeness	5

SOFT CIRCUIT SEWING KIT

Make: MAKER MADE

Sternlab $15 makershed.com CSTL1

An introduction to sewing with soft circuits, this fantastic kit teaches you how to augment your garments or needlework with LEDs. There's a free video tutorial as well as step-by-step instructions, and the kit includes everything you need to get started; Jawa doll not included! *–Arwen O'Reilly Griffith*

Complexity	3
Components	5
Documentation	5
Community	5
Completeness	4

Sashiko Daisies

TaDaa Studio LLC $14 tadaastudio.com

Sashiko embroidery is a Japanese needle-art that can be both meditative and addictive. Colors are worked into the design by making "little stabs" along the printed lines, creating a surprisingly complex final piece. Once complete, the ink washes out, leaving only your perfect sewing. TaDaa provides beautiful thread, sashiko needles, a leather thimble, and a linen base, as well as directions in both English and Japanese that are charming and fun. *—BM*

Complexity	3
Components	5
Documentation	5
Community	3
Completeness	5

Nat Wilson-Heckathorn (OctopusFriend and Sashiko Daisies); Bethany Mann (Soft Circuit - Jawa Doll)

PAPER CRAFTS

HOT LAMINATOR KIT

Purple Cows $59 craftzine.com/go/laminate

Complexity	1
Components	5
Documentation	5
Community	3
Completeness	5

I save recipes on cards and always get bits of food or water on them, but laminating them with this hot laminator kit makes wiping them off a breeze. Use it for scrapbooking or for special photos you want to protect, or make your own laminated crafts such as luggage tags, signs, and more. Any crafter will find some use for this kit, and its compact size makes it easy to store. *—NZD*

FINGER MAGIC ORIGAMI KITS

Origami Bijou $10 origamibijou.com

Complexity	5
Components	5
Documentation	3
Community	5
Completeness	5

Origami kits always intrigue me, but after folding a few animals I wonder what it's all for. So when I discovered Finger Magic, I thought, origami with a purpose! Not only do the kits teach fresh origami like Small World-style elephants, 3D tulips, and butterflies, but some kits come with greeting cards and envelopes. Just attach your paper gems to make stunning cards. *—Carla Sinclair*

KIT MAKER

MADE BY MOXIE

MOXIE

madebymoxie.com

Moxie is a cat-owning, pinball-playing, book-writing, kit-making fiber artist with a wit as sharp as her signature tool, the felting needle. Her art is beautifully executed, emotionally provocative, and has been featured in galleries across the country. Her designs make people say, "What is that? I have to touch it."

She began needle felting in August 2006, and she posts her work online, teaches felting, and instructs the masses at Maker Faire. After almost every lesson people ask, "Where can I find these materials?"

Moxie realized that in order to turn people on to needle felting, she would first have to provide the proper materials. Her supplies consist of high-quality wool batting, eco-foam pads, and felting needles, plus she adds a creative spin, using everything from cookie bags to Frappuccino cups as packaging, and sprinkles some irreverence into her clear instructions.

Moxie makes kits because she genuinely wants people to have as much fun as she does needle felting.

–Brookelynn Morris

SIEGE & BALLISTICS

SUITABLE FOR SERIOUS DART FLINGING.

ATLATL KITS

Thunderbird Atlatl $42 and up
thunderbirdatlatl.com

Complexity	2
Components	5
Documentation	4
Community	4
Completeness	4

If you've ever wanted to hurl spears to bring down a woolly mammoth, then these two kits from Thunderbird Atlatl are the way to go. The Nanticoke and Kanakadea kits are both high quality and simple to build, so with a little time and effort you can make a very nice-looking atlatl suitable for serious dart flinging.

The kits include everything you'll need except for wood glue, plus a brief history of the atlatl and instructions for casting darts. The kits can be purchased with three or seven darts, or none at all for those adventurous enough to make and experiment with different dart lengths and sizes. Additional darts of various styles are available from Thunderbird.

–Brian Melani

DESKTOP BATTERING RAM? I THINK YES.

MEDIEVAL BATTERING RAM

RLT Industries $35
rlt.com/12141

Complexity	3
Components	5
Documentation	4
Community	2
Completeness	4

Desktop battering ram? I think yes. This small kit is a lot of fun to build and use. It takes some time to put together and uses a fair amount of wood glue, but the instructions are clear and easy to read.

The kit comes with two ½"-thick boards that are CNC'ed out with all of the pieces of the ram, plus a dowel and some twine. All you need to do is carefully finish cutting out the pieces and glue them together.

Once you've assembled your battering ram you're ready to storm the walls of the nearest cubicle. *–BM*

CAPABLE OF HURLING A PROJECTILE A RESPECTABLE 200 FEET!

F.A.T. 3000 GUILLOTINE TREBUCHET

RLT Industries $169
rlt.com/10101

Complexity	3
Components	5
Documentation	4
Community	2
Completeness	4

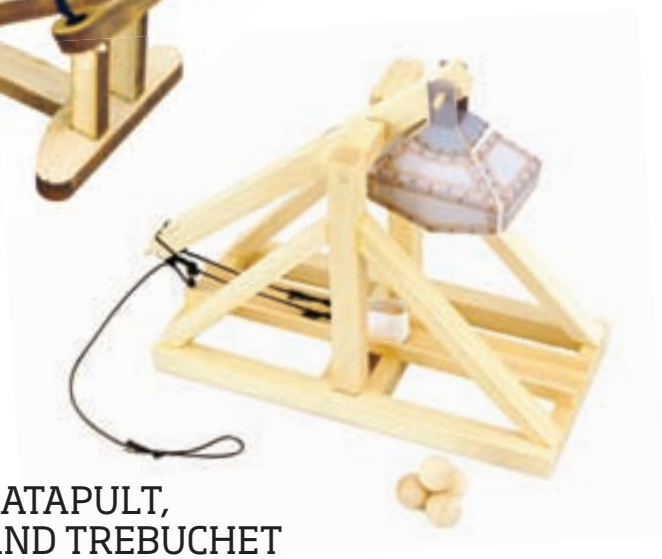
I've built my share of catapults (*see MAKE Volume 28, "Gravity Catapult"*), and this floating-arm kit has thoroughly impressed me. The parts come pre-cut in solid ash, and you clip off tabs to remove them, just like the plastic models I built as a kid. A file will help clean up the tabs.

It's put together with wood glue, so use one with good tack or you'll do a lot of waiting. The instructions call for two clamps, but you'd be much better off with eight or more. Spring clamps provide suitable force and won't mark up your wood parts.

After all your satisfying work, you end up with an impressive 34-inch trebuchet, capable of hurling a small, dense projectile a respectable 200 feet!

–Daniel Spangler

THREE GREAT STARTER KITS FOR MAKING SMALL TABLETOP SIEGE WEAPONS.



TABLETOP CATAPULT, BALLISTA, AND TREBUCHET

Abong $20 and up
abong.com

Complexity	2
Components	5
Documentation	5
Community	2
Completeness	4

These three great starter kits for making small tabletop siege weapons pack quite a kick. They're simple to build, and include well-documented, easy-to-follow instructions. All components are made of quality materials accurately machined and drilled.

The Ballista kit is built of laser-cut hardwood and is a real blast to assemble and fire. It's a bit more difficult than the other two, due to the fact that you need to "power up" the ballista by twisting the torsion skein. The finished weapon measures six inches tall and fires small wooden projectiles 30 feet.

The Catapult (onager) and Trebuchet are fun to fire too – reaching 12 feet and 18 feet, respectively. *–BM*

DESKTOP TREBUCHET

RLT Industries $40
rlt.com/10421

Complexity	3
Components	5
Documentation	4
Community	2
Completeness	4

RLT Industries has gone above and beyond with its Desktop Trebuchet kit. Each piece of wood is carefully chosen and precisely computer-cut. All the required tools can be found around your house or at a hobby shop, and the instructions are very detailed. However, as instructed, I used wood glue on the main frame and supports, but it didn't hold well. So I resorted to a hot glue gun, which worked perfectly. The build took about four hours.

The Desktop Trebuchet kit comes with four wooden balls to fire, and it shoots about 15 feet. I showed it to my engineering club, and we fired circus peanuts with it. (One of my club members ate all the peanuts.) It's a great kit for the model hobbyist who's just starting out. Overall, RLT has done a great job with this one!

–Robert M. Zigmund

WHEELS

THE TRUE REWARD IS DRIVING A FEW HUNDRED MILES DOWN THE INTERSTATE AND NOT SEEING YOUR FUEL GAUGE MOVE.

Diesel to Veggie Car Conversion

Greasecar Vegetable Fuel Systems $1,550
greasecar.com

Complexity	3
Components	5
Documentation	4
Community	5
Completeness	5

Whether your motivation is the environment, the economy, independence, or you simply despise the oil companies, converting your diesel vehicle to run on waste vegetable oil (WVO) can truly be a rewarding experience. (You can get WVO free from restaurants, preferably higher end. Luckily for me, my brother-in-law is a head chef, and he has access to WVO.)

Greasecar sells complete conversion kits for diesel Volkswagen, Volvo, BMW, Mercedes-Benz, and Peugeot cars, and Ford, GM, Dodge, and Isuzu vans and trucks. I could not be more pleased with the results of converting my 2004 Jetta TDI Wagon to run on WVO. The kit supplies all necessary components, which upon installation revealed high quality and excellent fit and features. Written instructions and a professional installation CD made the project a complete success for this weekend mechanic.

The neat part about the kit is that it doesn't compromise the car's original diesel system. You start the car on diesel and, once up to temperature, you transition to WVO either manually or automatically. Prior to shutdown, a simple button on the onboard controller initiates back-flushing of the WVO lines with diesel fuel so they won't get clogged with WVO when the car cools.

Once installed, the operation is incredibly simple. The true reward is driving a few hundred miles down the interstate and not seeing your fuel gauge move ... wow!

—Benjamin J. Mansi

SOUTH-POINTING CHARIOT KIT

RLT Industries $59
rlt.com/14201

Complexity	3
Components	4
Documentation	4
Community	3
Completeness	3

Indie makers RLT Industries of New Braunfels, Texas (see Siege Weapons kits on page 72), sells this lovely wooden model kit of the classic "south-pointing chariot" mechanism. Set the chariot down with the vane pointing in an arbitrary direction – south, north, whatever – and a geared differential connected to the wheels will keep it pointing the same direction regardless of which way the chariot turns. Their version went through eight prototypes to get the gearing just right and seems like a helladeal at $59.

–Sean Michael Ragan

Benjamin Mansi (under hood)

Bike Motor Kit

Gas Imports $180 bikemotorkit.com

Complexity	3
Components	3
Documentation	2
Community	3
Completeness	3

I was reading Boing Boing one day and saw a link to this bicycle motor kit, consisting of a 66cc two-cycle engine, drive mechanism, gas tank, muffler, and controls.

The ad brought back kid-time memories for me, as I had dreamed of one day owning a Whizzer, the classic motorized bicycle. It was the only vehicle you could purchase new during World War II. Now I could make one!

The kit arrived from China in three weeks. I opened the box to find that every nut, bolt, washer, and other sundry parts were not packed in tidy little plastic bags but were loose and had obviously rolled around in the box during its journey to me. I had no idea if parts were missing, as there was no assembly manual either.

I went online and found an assembly manual PDF and an assembly video at Gas Bike (gasbike.net). (They also sell a variety of bike motor kits.) Then I picked up a cheap used mountain bike.

Now for the coup de grace – the engine and control mounting! Actually, the process went quite well. The kit uses a chain-driven sprocket that clamps to the rear wheel's spokes. I found I was missing a part and readily located a replacement at a scooter shop.

Since the now-motorized bike has no starter, I had to get on, aim it downhill, let out the clutch, and hope it started. It did! A nice pop-pop-pop noise like a baby Harley came from the muffler. I turned it uphill and was amazed at the torque that came from that tiny engine.

–Lew Frauenfelder

FREERADICAL CARGO BIKE CONVERSION

Xtracycle $335 and up
xtracycle.com

Complexity	2
Components	3
Documentation	4
Community	5
Completeness	4

I've been living car-free for 12 years. When I first saw Xtracycle's cargo bike conversion kit, I was impressed by the broad utility of the design; it can be used to haul cargo and also passengers. I decided to build the ultimate people-and-stuff hauler so I could pick up friends who don't bike and we could go places.

I got the FreeRadical Classic extension kit with cargo deck and giant panniers, and added the WideLoader cargo shelves and KickBack kickstand. Xtracycle favors a mountain bike platform, not road, because the wheels are stronger. I bought a 2002 Cannondale MT2000 mountain tandem with a stong, American-made aluminum frame, and hydraulic disc brakes and quality tires for safety.

If you have any background in bikes, the kit is easy. Components are good quality; a "snap deck hook" failed on me, but I'm a heavy-duty user. The documentation is good, and if something wasn't mentioned, a quick YouTube search had it figured out — the Xtracycle community is rad, and totally open source.

The kit bolts to the bike in three strong and strategic places: the dropouts and rear triangle near the bottom bracket. Moving the rear wheel back 15 inches doesn't affect the handling on such an already-long bicycle. From my local bike shop I got a 10-foot hydraulic cable, a tandem rear derailleur cable, and another chain. I completed my cargo-bus-cycle with a Rock the Bike Mothership sound system. Now I ride around with my friends listening to music like we used to do in a car!

—Lucas French

Garry McLeod (top); Lucas French (bottom)

ROCKETS

GRAVITY KEEPING YOU DOWN? MAKE A ROCKET AND WATCH IT LIFT TO THE SKY.

Compressed Air Rockets Kit

Maker Shed $50
makershed.com MKRS1

Make: MAKER MADE

Complexity	2
Components	4
Documentation	4
Community	2
Completeness	4

I was looking for something to do with the kids. They raved about how much fun the rocket launching was at Maker Faire, so I brought some of that fun home with this kit, which is based on Rick Schertle's project from MAKE Volume 15 (makeprojects.com/project/c/585). The kit is an easy build, one or two hours total, and the rockets go amazingly high — so high I could barely see them anymore. I guess that's high enough! The kit includes Rick's article, all the electronics, and the PVC parts cut to length. All you need to supply are a few common tools, glue, paper, tape, and an air compressor or bicycle pump.

—Marc de Vinck

WATER ROCKETS

Launch Pro Multi-Stage Starter Kit

EnVision Labs $88
envisionlabs.com

Ultimate Water Rocket Experimenter's Kit

AntiGravity Research Corporation $200
antigravityresearch.com

People my age remember red plastic toy rockets from childhood that you filled with water, pumped with air, and watched as they leaped dozens of feet into the air. Well, things have gotten far more serious in the world of water-powered model rocketry, and hobbyists are reaching heights upwards of 800' using plastic soda bottles, thin wood or plastic for fins, tape, glue, a tire air valve, and an air source such as a bicycle pump.

Where the DIYer goes, the kit maker soon follows. We recently spied these cool-looking kits from EnVision Labs and AntiGravity Research, both of which will allow you to build towering, multi-stage water rockets using special connectors. Watch for reviews on makezine.com.

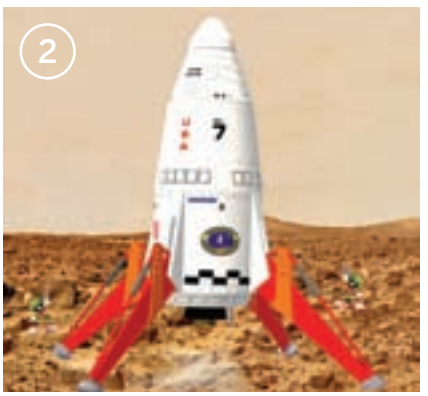
But even without a kit, you probably already have everything you need (or can easily aquire it). Consult aircommandrockets.com for advanced hydrorocketry ideas.

–Gareth Branwyn

See the build at:
makeprojects.com/project/s/446

SOLID-FUEL HOBBY ROCKETS

BY STEFAN JONES,
HOBBY ROCKETEER



1. Astra 1

Quest Aerospace $11
questaerospace.com

Complexity	1
Components	4
Documentation	4
Community	2
Completeness	4

Hobby rocketry leader Estes Industries makes more than a dozen inexpensive launch sets (launch pad/rod, launch controller) for beginners, but their included rockets are either pre-built or not much of a challenge. For a good first build, I'd instead suggest the Quest Astra 1. Its balsa fins are mounted "through the wall," making it easy for beginners to put them on straight. You can put it together with CA adhesive ("crazy glue") and have it ready to fly in 15 minutes.

2. Mars Lander

Semroc $46
semroc.com

Complexity	5
Components	4
Documentation	4
Community	3
Completeness	4

If you want a more challenging project that takes shape with some real cutting and sanding, small manufacturer Semroc produces high-quality balsa rocket kit reproductions. The Mars Lander, originally sold by Estes in the 1970s, is a beautifully realistic-looking spacecraft with spring-loaded landing legs. You can also try their Saturn 1B ($78), a 1/70 scale re-creation of the Apollo booster.

3. Big Daddy

Estes Industries $32
estesrockets.com

Complexity	2
Components	4
Documentation	4
Community	2
Completeness	4

A few rungs up the ladder toward high power is Estes' Big Daddy, a chunky, 3"-diameter model. While designed for D and E solid rocket motors, it can easily handle AeroTech's 24mm F motors. It's not much more difficult to build than the Astra, but bear in mind that an E motor has up to 16 times the power of the Astra's A.

4. Initiator Starter Set

AeroTech $200
aerotech-rocketry.com

Complexity	2
Components	4
Documentation	4
Community	2
Completeness	4

This starter kit has been the standard introduction to high-power rocketry (motor types H and above) for 20 years, and for good reason. The Initiator rocket is big (39"), looks sharp, and can handle a wide variety of motors with its 29mm reloadable motor casing. You can put the kit together in an evening with 5-minute epoxy. The included pad and launch panel are easy to use and transport; they won't handle truly huge models, but serious rocketeers generally fly their giant projects on shared club equipment.

5. Hi-Tech H45

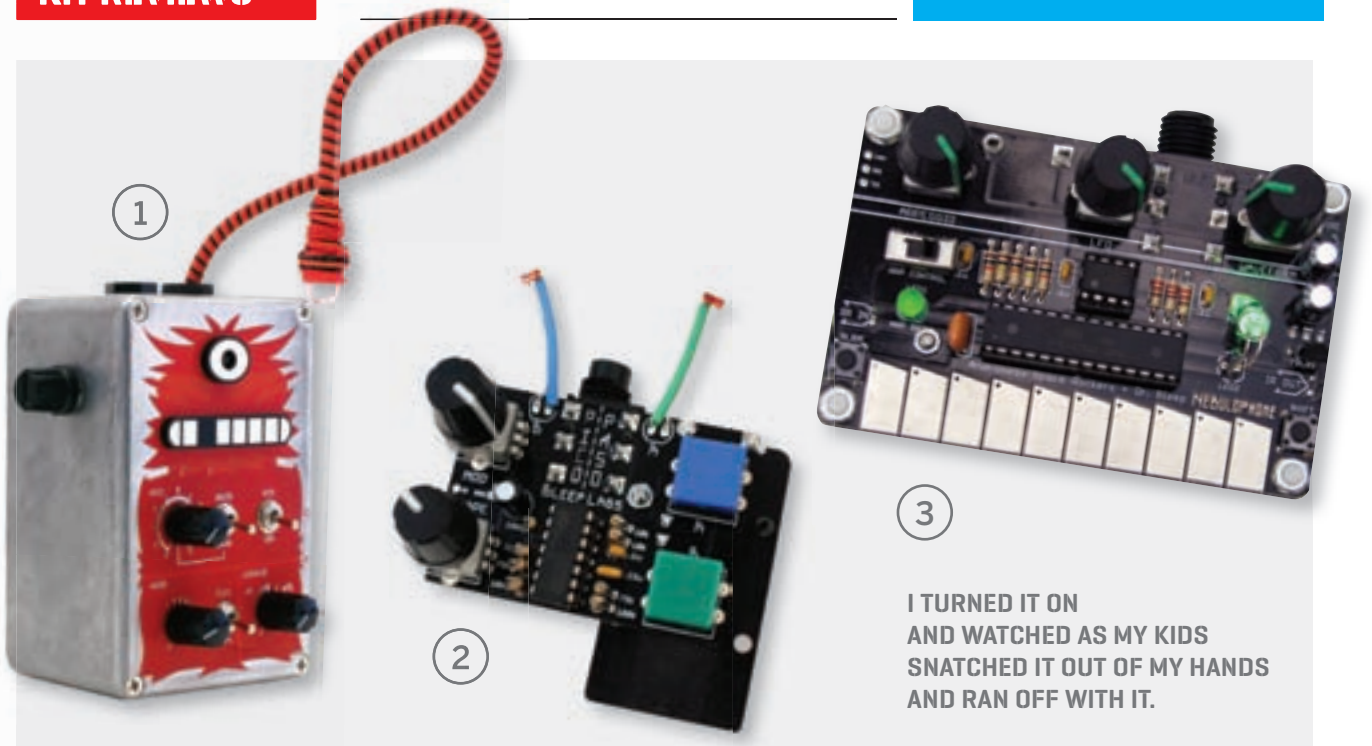
LOC Precision $70
locprecision.com

Complexity	3
Components	4
Documentation	2
Community	2
Completeness	4

If you want a more challenging high-power build experience, I like the Hi-Tech H45 kit. It's big (2.63" diameter and 49" tall), with sturdy plywood fins and a durable plastic nose cone, and it can handle motor types F through I. I got my first high-power certification on this model back in 1990. Good times!

KIT PARTY!

BY JOHN BAICHTAL,
GEEK DAD AND MAKE BLOGGER



I TURNED IT ON AND WATCHED AS MY KIDS SNATCHED IT OUT OF MY HANDS AND RAN OFF WITH IT.

BLEEP LABS

bleeplabs.com

1. Thingamagoop 2

Make: MAKER MADE

$75–$160

Complexity	4
Components	5
Documentation	3
Community	5
Completeness	4

Analog voltage-controlled oscillators (AVOs) make a variety of intriguing hums, beeps, buzzes, and loops, controlled by buttons, knobs, and sensors. These are fantastic group projects because once the soldering irons are all put down, you get an excellent payoff: you can have an impromptu concert. Bleep Labs, run by Austin, Texas, circuit bender and kit maker John-Michael Reed, produces a few AVO kits that I've built and had fun with.

The Thingamagoop 2 features a square wave amplitude modulator and triangle wave pulse width modulator, packed into a lovely silkscreened metal enclosure. The Thingamagoop's signature component is an LED on a bendable wire antenna called the LEDacle, which looks cool and, more importantly, interfaces with the light sensor hidden in the eye, making for a huge range of possible sounds.

I found the build to be rather challenging. It took me a couple of hours to make, with one or two tricky steps. One thing I appreciated was that unlike other Bleep Labs kits, you don't need anything but the kit itself to make cool music – there's no need to plug into anything. When I finally finished my Thingamagoop, I turned it on and watched as my kids snatched it out of my hands and ran off with it.

While the Thingamagoop is obviously kid-friendly, it offers some cool features for mom and dad to explore further. For instance, I'm intrigued that you can reprogram its ATmega328 chip using an Arduino.

2. Pico Paso

$25–$40

Complexity	3
Components	5
Documentation	3
Community	5
Completeness	3

This tiny, handheld synth features two light sensors, two pots, and two buttons. It's an easy build, even for newbies, soldering together very quickly with no difficult steps. I love how snug the little guy is, but this compactness comes at a price: no enclosure and no speaker. To hear the Pico Paso, you'll need a ¼" mono cable to connect it to a mixer or amp.

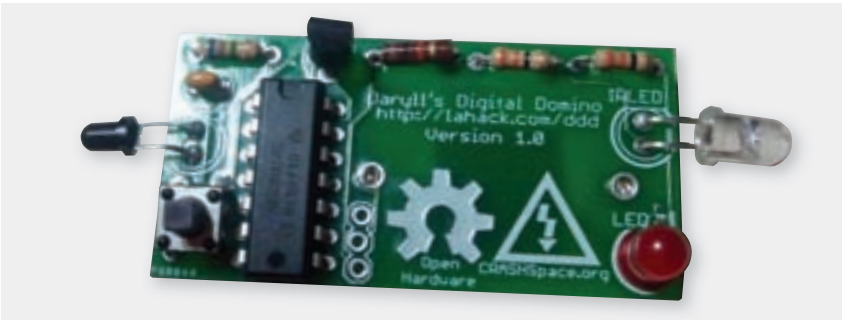
3. Nebulophone

$55–$80

Complexity	3
Components	5
Documentation	3
Community	5
Completeness	3

Another small synth from Bleep Labs, the Nebulophone is more robust than the Pico Paso. It packs three potentiometer knobs, two buttons, an LED/light sensor combo that serves as an analog low-pass filter, and a unique piano-like series of pads on the PCB that you can control with an alligator clip. It has a programmable sequencer, outputs six octaves, and features six arpeggio modes. For remote control fun, you can clock the arpeggiator over IR. Like the Pico Paso, you'll need to plug the synth into an amp to get any sound out of it.

Ask any hackerspace: kit-building parties are more fun (and memorable).



DIGITAL DOMINOS

Crash Space $20 store.crashspacela.com

Complexity	2
Components	5
Documentation	5
Community	3
Completeness	4

These Digital Dominos work just like regular dominos knocking each other down, only virtually. Each domino-sized PCB has a button that triggers an LED to blink (which corresponds to the domino "falling"). An IR sensor on one end and an IR LED on the other allow each domino to trigger any adjacent domino to blink, and so on.

Created by Daryll Strauss of Los Angeles hackerspace Crash Space, these open source boards come four to a pack and are the perfect large-group build for people just learning to solder. They're easy to assemble, and a hundred people building them can collaborate to create gigantic, blinking trails of light. Best of all, to see the dominoes fall another time, you don't have to stack them all back up. Just press the first domino's button again.

Coil Driver

Perth Artifactory $45

artifactory.org.au/kits/coildriver

Complexity	4
Components	5
Documentation	3
Community	4
Completeness	3

If you like high-voltage sparks arcing through the air (and who doesn't?), check out the Coil Driver, which drives an automotive ignition coil at audio frequencies. Like other musical kits, the Coil Driver makes a great group build because you can all make cool sounds together when you're done. However, while it's an easy solder, this kit may intimidate the casual maker because, let's face it, high-voltage current is scary.

Each board drives one automotive ignition coil, and you can control one or more using an Arduino microcontroller (not included). Designers Brett Downing and Daniel Harmsworth, of the Artifactory hackerspace in Perth, Australia, used these boards to build their Polyplasmic Arcophone, a giant instrument that features 13 Jacob's ladders, zapping out music!

Make: MAKER MADE

I INFORMED MY GIRLFRIEND THAT SHE WOULD HAVE TO "DRINK FOR SCIENCE!"

DrinkShield for Arduino (and DrinkDuino)

GfxHax $28

makershed.com MKGX01

Complexity	3
Components	5
Documentation	3
Community	5
Completeness	4

The DrinkDuino drinking game was the perfect excuse for me to get my first Arduino. After ordering the DrinkShield breathalyzer kit and an Arduino Uno to drive it, I hastily pieced it together on my living room floor. The kit was simple enough, all components were included, and the instructions online were quick and easy.

Once I finished the build and uploaded the software, I informed my girlfriend that she would have to "drink for science!" Needless to say, she happily did her part. The next several days were spent playing with it and whatever alcohol we could find around my office.

The open-source DrinkDuino Game software uses the DrinkShield API and is a big hit with everyone. It's simple enough for a drunk to play, but fun enough to keep them interested. DrinkShield developer Craig Smith is incredibly helpful, and when I had some issues setting up the game, he helped me stumble though. All in all, DrinkDuino is a must for any get-together featuring adult beverages. Cheers!

–Will Stone

FOOD

BY ARWEN O'REILLY GRIFFITH, MAKE EDITOR AND CULINARY MAVEN

Gear up and get cooking with this arsenal of pantry supplies and gadgets galore.

MEAT & CHEESE

1. Mozzarella Cheese Kit

Leeners $25
leeners.com

Complexity	3
Components	5
Documentation	5
Community	1
Completeness	5

I would happily eat my weight in cheese, so the idea of having fresh mozzarella whenever I want has very strong appeal. This kit makes it as easy as buying a gallon of (not ultra-pasteurized) milk. The clear instructions take any mystery out of the chemistry, and I went from hot milk to perfect curds to pulling mozzarella in under an hour. Perfecto! More ambitious cheese-makers can try Leener's Ultimate Cheese Making Kit to attempt hard cheeses.

2. Bacon Curing Kit

Leeners $20
leeners.com

Roasted, Smoked	
Complexity	2, 4
Components	5
Documentation	5
Community	1
Completeness	5, 4

Bacon is enjoying the limelight these days, showing up in everything from chocolate to donuts! If you really want to hop on this fat fad, brine your own. It takes a week, but is incredibly simple and delicious. This kit's recipe book covers bacon, Canadian bacon, and pancetta. Note to the truly dedicated: invest in a smoker. My oven-roasted bacon was tasty, but I gave half of my pork belly to a neighbor, and his hickory-smoked slices really sizzled.

3. Corned Beef and Pastrami Kit

Leeners $30
leeners.com

Corned Beef, Pastrami	
Complexity	2, 4
Components	5
Documentation	5
Community	1
Completeness	5

I've made corned beef every St. Paddy's day for years now, and have finally perfected my cocktail of pickling spices. Turns out I could have just gotten Leeners' Corned Beef and Pastrami Kit; theirs is just as good. The kit comes with absolutely everything you need except the brisket (including a scarily effective meat tenderizer), and you can take it a step further and smoke yourself a mean pastrami out on the grill. Yum.

PRESERVATION & FERMENTATION

4. Water Bath Canning Kit

Granite Ware $50
makezine.com/go/canning

Complexity	3
Components	4
Documentation	2
Community	1
Completeness	5

There's nothing like prying open a jar of gleaming, homemade strawberry jam in January. This kit is a classic and contains everything you need to get started. It's worth it for the magnetic lid lifter alone! (How many times have I burned myself fishing around the pot for lost lids?) For smaller batches, I like steam canners to cut down on all that boiling water, but when you're up to your elbows in tomatoes, you'll definitely reach for this capacious pot.

You may need an additional book, like Ashley English's *Canning and Preserving* (her cherry marmalade recipe is worth pitting cherries for). And if you prefer your jam on the tart side, I recommend Pomona's Pectin, which uses calcium instead of sugar to give you more sweetness control.

Best of all with this kit: everything fits back in the pot, so it doesn't take up tons of space in your cabinet.

5. Vegetable Fermenting Gear

Cultures for Health $20 starter, plus $62 for cookbook, mandoline, and jar
culturesforhealth.com

Complexity	1
Components	5
Documentation	4
Community	4
Completeness	2

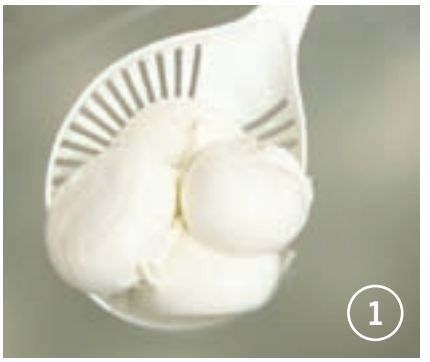
To make sauerkraut, all you really need is cabbage, salt, and a jar with a lid, but you can make your life much easier with a mandoline slicer, vegetable starter culture, and fermenting crock from Cultures for Health. (A copy of *Wild Fermentation* by Sandor Katz will only help the cause.) They carry charming crocks from Poland and Germany, but I love the Fermented Vegetable Master jar because you can keep an eye on your veggies through the glass, and the air-lock in the lid adds some space-age chic to your kitchen. Questions? Check out the forums, videos, and how-to articles on their website.

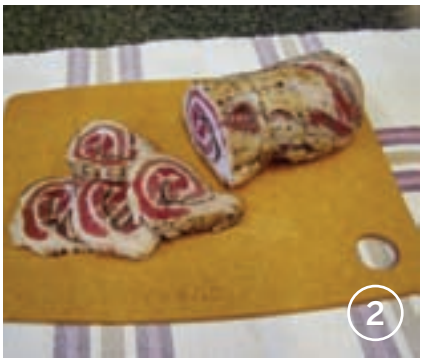
6. Bread Making Gear

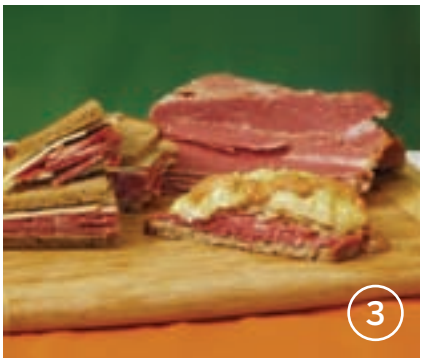
Cultures for Health
$13 starter, up to $50 for other tools
culturesforhealth.com

Complexity	3
Components	5
Documentation	5
Community	4
Completeness	2

While not exactly a "kit," Cultures for Health has everything you need for making sourdough bread: 15 starters from all over the world, clear instructions, and a great selection of useful bread-making tools, like cookbooks, dough scrapers, bread bags, and baker's blades for scoring that classic ridge down the middle of your loaf. I experimented with a New Zealand rye starter, and after a week of tender care and regular feeding, it was bubbly and ready to go. The next day, I pulled my first loaf of warm, tasty raisin rye bread out of the oven. Next up: I'm going to tackle a classic San Francisco sourdough.







DESSERT

7. Mayan Magic Chocolate Making Kit

Mayan Magic $25
makezine.com/go/mayan

Complexity	2
Components	5
Documentation	5
Community	2
Completeness	5

Chocoholics, take note! This kit allows you to make your flavor fantasies come true. It's got everything you need to make basic, agave-sweetened chocolate, but I used honey instead and added lemon zest to create something out of this world. Ruffled paper cups are included, so the presentation is worthy of your sweetheart. After a few days, the chocolate took on a grainy texture, so eat it quickly (that won't be hard).

GROW YOUR OWN

8. Pre-Activated Shiitake Mushroom Mini Farm

Far West Fungi $20
farwestfungi.com

Complexity	2
Components	5
Documentation	3
Community	3
Completeness	5

Who'd believe a sawdust log in a plastic bag could turn into a magical mushroom forest before your eyes! My first harvest was bounteous and the shiitakes delectable, but careful attention to growing conditions was required to yield multiple crops of mushrooms rather than mold. If you get 3–5 harvests, the kit is a bargain; but regardless, it's worth it just to be able to pluck those lovely 'shrooms right next to your dinner plate.

9. Spirulina Growth Kit

Algae Lab $249
algaelab.org

Complexity	2
Components	3
Documentation	4
Community	4
Completeness	5

You don't have to depend on commercial growers or expensive powders to get your spirulina fix. With this kit, you can have it fresh and alive, anytime. I made a few modifications to help mine grow faster and prevent clogging, like replacing the intake line with rubber tubing and swapping the bubble wand for a stone and filter. If I'd known it was so easy, I'd have done it long ago.

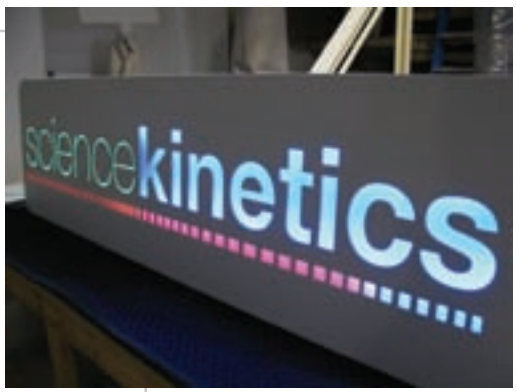
Build your own spirulina superfood tank: see MAKE Volume 27, page 92.

–Vicky Glisson

iStock (1, 5, 6); Arwen O'Reilly Griffith (4, 7); Sam Murphy (9)

ShopBotter Jeff Shapiro makes learning fun with Science Kinetics

Jeff Shapiro is a former 6th grade science teacher whose company, Science Kinetics, designs and fabricates interactive educational displays for museums. Jeff began making hands-on displays as teaching tools for his classroom, and turned this passion into his fulltime business in 2005. The company's work is being enjoyed by thousands of visitors to museums across the U.S. and five other countries around the globe. "*My ShopBot CNC is hands-down the most valuable tool I have ever owned. I don't think there is one exhibit I sell that doesn't have components fabricated on the ShopBot. The accuracy of the tool enables us to produce moving displays that work perfectly and can withstand use by kids and adults for years and years!*"



WHERE Grove City, Ohio

BUSINESS Science Kinetics sciencekinetics.com

SHOPBOT PRSstandard 96 X 48

INSPIRATIONS "My initial inspiration to start Science Kinetics was sparked by the reactions of visitors to the interactive exhibits at the Center of Science and Industry where I worked while attending Ohio State. To me, a well-designed exhibit has an almost magical ability to speak to a diverse audience. A child may take away something completely different than an adult but that doesn't really matter. If the exhibit made an impression it did its job!"

WHAT'S NEXT "Developing a traveling exhibit to be leased by museums for a few months at a time. I'm also very interested in the idea of designing interactive, electro-mechanical art exhibits."

BEVERAGES

BY JOHN EDGAR PARK, MIXOLOGIST

MAKE YOUR OWN KOMBUCHA AT HOME.

KOMBUCHA STARTER KIT

Oregon Kombucha $16
oregonkombucha.com

Complexity	2
Components	4
Documentation	3
Community	3
Completeness	3

What's kombucha? It's a refreshing, lightly sweetened, sparkling tea drink that is naturally fermented (yet non-alcoholic). The Oregon Kombucha kit comes with everything you need to make your own kombucha at home. The instructions are clear and easy to follow. Boil a gallon of water, brew the tea satchel, dissolve the sugar, let it cool, then add the live kombucha culture, and wait at least a week for it to do its thing. And by "it" I mean the SCOBY (symbiotic culture of bacteria and yeast). The reusable SCOBY is the living, pancake-like mass that forms on top of the tea and gives carbonation and added flavor to the beverage.

EASY AND AESTHETICALLY BEAUTIFUL.

HARIO COLD WATER COFFEE DRIPPER

Hario $251
roustaboutproducts.com

Complexity	2
Components	5
Documentation	3
Community	2
Completeness	5

Iced coffee is refreshing and delicious, but I've never been able to make it as well as I'd like. As it turns out, I was doing it wrong. Rather than prepare it with a traditional hot brew method, I should have been cold brewing it. This reduces acidity and produces a concentrated flavor that stands up well to ice, sugar, and cream. The Hario Cold Water Coffee Dripper makes this easy and aesthetically beautiful, with its clear stand, lab-style glass, and high-quality components. The instructions are in Japanese, but I figured it all out from the illustrations (and a peek at some web videos). Place grounds into the filter chamber, wet them, then fill the reservoir with cold water. Open the drip valve to a 1-drip-per-second rate, then wait a few hours for liquid gold to brew through to the carafe.

A GREAT WEEKEND PROJECT FOR THE WHOLE FAMILY.

GINGER ALE

Maker Shed $16
makershed.com MKCT08

Complexity	2
Components	4
Documentation	4
Community	2
Completeness	4

The Brew It Yourself Ginger Ale kit is a great weekend project for the whole family. It comes with easy-to-follow instructions, ginger ale flavor extract, yeast, a funnel, and two blank labels. My kids enjoyed measuring, mixing, and heating ingredients, proofing the yeast, and bottling in two 2-liter bottles, adorned with their custom-made labels. After fermenting and refrigerating, the ale was highly carbonated (we made a spectacular ginger ale fountain by accident), naturally sweet, and delicious.

ALCOHOLIC BEVERAGES

PERFECT FOR THE MAD-SCIENTIST MIXOLOGIST IN YOUR LIFE.

MOLECULAR COCKTAILS

ThinkGeek $80
thinkgeek.com

Complexity	4
Components	5
Documentation	5
Community	3
Completeness	4

The Molecular Cocktails Starter Kit is the perfect gift for the mad-scientist mixologist in your life. It comes with the tools, chemical compounds, and information needed to create gels, liquid-filled spheres, foams, and UV-reactive glowing drinks. The included book contains chapters on foundational techniques derived from molecular gastronomy, as well as 50 recipes.

TASTY, FIZZY, AND TIPSY FUN!

SPIKE YOUR JUICE

Spike Your Juice $10
spikeyourjuice.com

Complexity	2
Components	4
Documentation	3
Community	2
Completeness	3

Spike Your Juice is a simple introduction to home fermentation. The kit comes with enough yeast packets for six batches, an airlock with rubber stopper, and clear instructions. To brew a batch of alcoholic juice, add one yeast pack to a 64oz bottle of juice (such as grape or cranberry), shake, stopper with the water-filled airlock valve, and wait 48 hours. The yeast will digest the sugar, producing alcohol and carbonation. Tasty, fizzy, and tipsy fun!

BREWING FOR THE QUALITY-CONSCIOUS QUAFFER.

BROOKLYN BREW BEER MAKING KIT

Make: MAKER MADE

Brooklyn Brew Shop $40
makershed.com MKBBS1

Complexity	4
Components	4
Documentation	4
Community	4
Completeness	4

The Brooklyn Brew Shop 1 Gallon Beer Making Kit is the perfect introduction to brewing for the quality-conscious quaffer. Instead of the typical can of malt extract, you'll learn about the true steps of making a grain mash, sparging, hopping, yeasting, fermenting, bottling, and then drinking a delicious homebrew. I made a tasty IPA, though they offer many other styles. One of the most inspired things about this kit is its size – small enough to do on a stovetop, more manageable than the typical 5-gallon size. Includes malted barley blend, hops, yeast, glass fermenter, airlock, tubing, thermometer, tubing clamp, sanitizer, stopper, and blowoff attachment.

CARBONATE COCKTAILS, OR EVEN FRESH FRUIT!

PERLINI CARBONATION KIT

Perlage Systems $199
perlini.biz

Complexity	3
Components	5
Documentation	5
Community	3
Completeness	4

Open the cool aluminum briefcase and remove your weapon of choice. Charge the pistol grip with a 16-gram CO_2 cartridge. Fill the lower shaker chamber with gin, maraschino liqueur, lemon juice, Creme de Violette, and ice. Thread the shaker top and valve onto the lower chamber. Inject CO_2 into the shaker. Shake. Settle. Open. Pour. You've just made a delicious, sparkling Aviation.

You can use the Perlini system to carbonate cocktails and other drinks that won't work in a traditional home carbonation system, thanks to the large opening of the three-part cobbler-style shaker. I even used it to carbonate some fresh strawberries. It comes with excellent instructions (printed, and on a USB drive) that include recipes, solid explanations of the science of carbonation, a formula to calculate optimal booze-to-ice ratios, and other important mixological physics.

AGE IN 3–6 MONTHS WHAT WOULD NORMALLY TAKE A FEW YEARS.

WHISKEY AGING KIT

Woodinville Whiskey Co. $150
woodinvillewhiskeyco.com

Complexity	2
Components	5
Documentation	4
Community	3
Completeness	4

Just because you don't own a distillery doesn't mean you can't have a hand in making your own whiskey. Whiskey starts its life as a clear, nearly flavorless spirit; it's the aging process that provides the beautiful brown color and most of the smooth, smoky flavor. The Age Your Own Whiskey Kit provides all you need to age whiskey in much less time than you may think. The kit comes with a desktop-sized 2L charred oak barrel, two 750ml bottles of "white dog" unaged whiskey, a funnel, two tasting glasses, and clear instructions. Swell the barrel with water to make it watertight, then drain, pour in the young whiskey, and wait. Thanks to the high proportion of surface area to volume, you can age in three to six months what would normally take a few years. I tasted mine after the first week and it's already developing color, smoothness, and smoky, caramel flavor.

John Edgar Park

RECIPE

J. EDGAR'S AROMATIC BITTERS №1

Invigorate your newly carbonated cocktails, sodas, and aged whiskey with homemade bitters.

INGREDIENTS

151-proof grain alcohol, 375ml
100-proof bourbon, 375ml
Zest of one lemon peeled with a vegetable peeler
Quinine extract, ¼tsp from a health food store
Wormwood extract, ⅛tsp from a health food store
Tellicherry peppercorns, 2tsp
Cinnamon stick
Fresh ginger root, 2" piece
Allspice berries (6)
Cloves (4)
Dried cherries, ⅛c
Vanilla bean split in half lengthwise, with its seeds scraped and reserved to add to jar
Raw sugar, ¼c

DIRECTIONS

1. Put all ingredients, except for sugar, in a large glass jar, closing it tightly.

2. Store jar in a cool, dark place for 13 days, shaking it daily.

3. On the thirteenth day, filter liquid into a clean jar through a sieve, reserving solids.

4. Place filtered solids into a saucepan, along with ½c of water. Bring to simmer, stirring occasionally, for 15 minutes, in order to extract maximum flavor.

5. Strain simmered liquid through sieve or cheesecloth, and then combine with other jar of liquid.

6. Filter liquid through a coffee filter or AeroPress to remove small particles.

7. Heat sugar in a small saucepan over medium-high heat, stirring until it caramelizes and froths, then add it to bitters.

8. Shake jar until burnt sugar dissolves, then let bitters cool.

9. Bottle and apply directly to your tongue to relieve the fantods, or enjoy a dash or two in most any drink for added flavor.

AUDIO GEAR

Crank it up with these audiophile projects.

1. MSA-R MIDI Decoder

Highly Liquid $50–$67
highlyliquid.com

Complexity	3
Components	4
Documentation	4
Community	3
Completeness	4

This kit gets top marks for ease of assembly and low price, and because it's preprogrammed to do all the heavy lifting, all you need to do is solder it together and attach it to the device of your choice. It'll take an average-skilled solderer 1½ hours to assemble, and from there the possibilities are endless. Circuit-bent devices, kinetic toys, and things that light up can all be linked and sequenced into a sound-and-light show that'll impress onlookers with your ingenuity and resourcefulness. And it's fun!

–Michael Una

2. Elekit TU-879S Stereo Tube Amplifier

Tube Depot $600
tubedepot.com

Complexity	3
Components	5
Documentation	5
Community	2
Completeness	5

The great thing about this kit is the variety of skills you'll learn. Not only do you end up with a warm-sounding tube amp, but you also learn how all these audio components are produced, as well as proper soldering technique, orientation of polarized capacitors, spacing of large-value wirewound resistors, and heat sinking of transistors. It's relatively straightforward to build, but if you're a novice, seek out a mentor with electronics experience to offer some guidance.

–Jake Spurlock

3. PoddWatt Series 1 Amplifier

Make: MAKER MADE

OddWatt Audio $575
oddwattaudio.com

Complexity	5
Components	5
Documentation	4
Community	4
Completeness	5

Just one listen to this home-built, high-end tube amp, and you'll quickly discover that there's more to that classic song you've been listening to for years. It has nothing to do with nostalgia – tubes just sound more musical than pure solid state, and the PoddWatt is a prime example.

So, what can you get from a mid-priced tube amp kit nowadays? If you're willing to play by the rules, the answer is quite a bit. The PoddWatt produces a smooth sound that rarely offends, and as a kit, the build is fantastic. The instructions are thorough, and the components USA-sourced. The best part? The listening just gets better with time.

–JS

SPEAKERS

4. TriTrix MTM Speakers

C&W Audio Labs $259/pair
parts-express.com

Complexity	3
Components	4
Documentation	4
Community	5
Completeness	4

Speaker design master Curt Campbell has created several dream kits for the audiophile, including the TriTrix. Featuring two 5.25" Dayton Audio woofers and a single tweeter in MTM format, the final product has an easy, 8Ω load that can be used for audio or home theater systems. The transmission line kit includes precision-cut MDF for making the cabinets, which came together for me with a little wood glue and some clamps (I used five to make it easy on myself). With instructive online manufacturer videos and priced at only $259/pair, these speakers blow the roof off any competitor.

–JS

5. Seas Idunn 2-Way Speakers

Seas Prestige $698/pair
madisoundspeakerstore.com

Complexity	2
Components	5
Documentation	4
Community	3
Completeness	5

Named after the Norse goddess of youth, the Seas Idunn kit sets a high standard for DIY speakers. Cabinets come fully assembled in black ash, cherry, or maple, and the crossover also comes prebuilt, so installing it is just a matter of affixing it to the boxes and attaching the drivers. All told, the build took me about two hours using basic hand tools. To get speakers that look and sound this good, you'd normally pay several thousand dollars.

–JS

RETRO

6. Premium Berliner Gramophone Kit

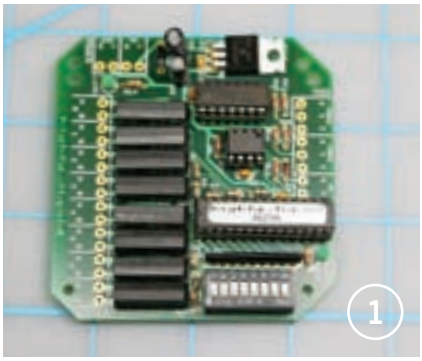
Gakken $120
makershed.com MKGK28

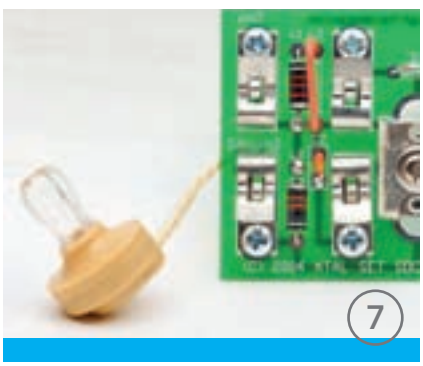
Complexity	3
Components	4
Documentation	4
Community	1
Completeness	4

Constructed from a motor and various bits of wood, plastic, and styrofoam, this retro gramophone kit offers the allure of carving grooves into compact discs and Dixie cups with a sewing-needle-based pickup and playback assembly.

Illustrated instructions in both Japanese and well-translated English are included, and the hour-long assembly only requires a screwdriver, some scotch tape, and a battery. This kit definitely delivers on the archaic, hands-on audio experience. Recommended for all ages.

–Adam W. Kempa





7. XS-402 Little Wonder Crystal Radio Kit

Xtal Set Society, Inc. $19
midnightscience.com/kits.html

Complexity	2
Components	5
Documentation	4
Community	5
Completeness	4

Many middle-aged DIY enthusiasts have constructed a crystal radio set; it's such a joy to pull radio signals out of the ether using only the radio signal itself for power.

Unlike traditional crystal sets, the XS-402 uses a molded, high frequency choke, eliminating the frustrating coil-winding process, and features large solder pads, great for learning to solder. It's a perfect project for adults to build with kids, and it serves as a great tool to teach basic radio theory, soldering, and handling of electronic parts and PCBs. If you're interested in "old school" radio technology or want to learn more complex skills, this is the kit for you.

–Thomas Arey N2EI

KIT MAKERS

ODDWATT AUDIO
BRUCE HERAN & RODNEY BRINKER

oddwattaudio.com

OddWatt owners Bruce Heran and Rodney Brinker met in 2009 after Heran posted a kit build on diyaudioprojects.com. Brinker was working on the same kit, and they realized they had a lot in common, especially their sense of what makes a quality kit.

"We liked the idea of just building the thing right the first time using quality parts," says Brinker.

Using their unique OddWatt amplifier circuit as a basis, they knew they had something effective and different. "The circuit is deceptively simple," they write. "The signal path has only one capacitor and one transformer."

Heran focuses on designing solid products that last, and Brinker strives to provide instructions so clear that even the unskilled will enjoy success. Hundreds of hours go into each kit, from concept to completion. It's no wonder their motto is "Good Listening!"

Look for new kits coming soon, including a large power amp, a phonograph preamp, and a single-watt vacuum tube kit for beginners.

–Goli Mohammadi

MUSICAL INSTRUMENTS

Rock out and celebrate making your own instruments and effects.

H3125 Ukulele

Grizzly Industrial $23 grizzly.com

Complexity	4
Components	4
Documentation	4
Community	2
Completeness	4

Aspiring luthiers will find this a satisfying first project, with its pre-assembled mahogany body and ready-to-attach neck; you're left with the satisfying jobs of final assembly and finishing. The woods are nice despite the low price — the plywood fretboard being the only weak piece — and if you build it as instructed, you'll end up with a very nice entry-level ukulele. Experiment with techniques like body-edge binding and inlay work to take it up a notch. Whether you aspire to be an exotic island crooner or to start the next post-punk, all-toy-instrument band, a ukulele is just a nice thing to have around.

—Steve Lodefink

TENOR WOLFELELE UKULELE

Wolfelele Ukuleles $96
wolfelele.com

Complexity	2
Components	5
Documentation	3
Community	5
Completeness	4

It took me about 45 minutes (not including glue drying time) to put together a service-able ukulele from Wolfelele's precut wooden components. The well-designed parts fit together in a way that ensured it didn't end up crooked, and the triangular instrument sounds better than any other $100 ukulele I've played. The kit has everything you need, except wood glue, a Phillips screwdriver, sandpaper, and scissors. (I recommend that you refer to the online instructions rather than the paper ones as the former are more complete.) The website also has a downloadable teacher brochure and useful instructions on how to run a Wolfelele-building workshop.

–Mark Frauenfelder

MUSICAL INSTRUMENTS

PAINT IT, STAIN IT, OR CLASSICALLY DISTRESS IT.

SAGA ELECTRIC GUITAR: T-STYLE

Saga Musical Instruments $179
makershed.com MKSGTC10

Complexity	2
Components	2
Documentation	4
Community	3
Completeness	4

If you want an easy-to-build guitar that you can really make your own, this kit offers a blank canvas. You can paint it, stain it, or classically distress it to look like your favorite guitar idol. All the holes are pre-drilled, and the connections don't require any soldering. The headstock comes in a generic paddle shape to allow your imagination to run wild – I deliberated for ages before landing on the perfect style for mine. This kit takes you from making to rocking in no time.

SMOOTH TUBE OVERDRIVE.

THE PERSUADER TUBE DRIVE EFFECTS PEDAL

Mod Kits DIY $65
amplifiedparts.com

Complexity	4
Components	4
Documentation	4
Community	3
Completeness	4

Looking to get some clean preamp boost out of your guitar, and love the tone that vintage tubes offer? Check out The Persuader pedal from Mod Kits DIY. The Persuader can take the tone of your guitar from nice and clean to that warm, smooth tube overdrive. Easy to construct with the solid instructions, this pedal is built with the 12AX7 tube, but if you're looking to change up the tone, consider swapping in other tubes also available from Amplified Parts.

ADD THAT "EXTRA SPECIAL VINTAGE" TONE.

E.S.V. FUZZ PEDAL

BYOC $95
buildyourownclone.com

Complexity	2
Components	5
Documentation	5
Community	3
Completeness	4

Perfect for the hobby electronics musician, the E.S.V. Fuzz pedal adds that "Extra Special Vintage" tone to your electric guitar. The kit has a handy PCB design that makes soldering a breeze, and as a result I was able to put this kit together in about an hour. Follow the detailed instructions and you, too, will be playing with that nice and crunchy, vintage sound in no time.

Ben Lowe (Drone Lab)

BY JAKE SPURLOCK, MAKE WEB GURU AND AUDIOPHILE

IT LOOKS PRETTY RAD.

MOD 102 DIY GUITAR AMPLIFIER

Mod Kits DIY $215
amplifiedparts.com

Complexity	4
Components	4
Documentation	3
Community	3
Completeness	4

Musicians have long praised the tone of tube amps, and after a face-melting guitar solo, it looks pretty rad to have your amp glowing behind you on stage.

I love the simplistic, wholly utilitarian design of the Mod102's case, and the sweet tone it adds. The circuit design is point to point, giving beginners and experts alike an enjoyable project to put together, and to plug into.

ETHERWAVE THEREMIN

Moog Music $359 moogmusic.com

Complexity	4
Components	4
Documentation	3
Community	3
Completeness	4

Due to its hands-free interface (your body's interference with its electromagnetic field controls the sound), the theremin is famed for both its novelty and its importance in 20th-century music. When I started building this kit, I had little soldering experience, but the straightforward instructions made for a great introduction to the world of circuits. The wooden casing needs a brief sanding and varnish or paint, and the mostly constructed circuit board only requires soldering the components that determine tone and waveforms. Bonus: the kit comes with a hilarious performance DVD of Clara Rockmore, one of the first theremin players, and a somber demonstration by her granddaughter.

—Meara O'Reilly

DRONE LAB V2

Casper Electronics $230 casperelectronics.com

Complexity	4
Components	5
Documentation	4
Community	3
Completeness	4

As a newbie to synthesizers and most electronics, I found the Drone Lab V2 a rewarding kit to construct. This analog drone synthesizer is made up of four oscillators, each with tuning and volume control, that get mixed together and run through various effects. You can also run another synth, noisemaker, guitar, or whatever straight into it for all kinds of cool sonic interplay. The assembly is all soldered onto one PCB, eliminating the need for wiring and mounting, and although the construction and layout is solid, it does feel very DIY. So, how does it sound? In a word: awesome. The tuning controls allow you to dial in your drones by ear, but it's the effects that really make it playable on its own.

—Ben Lowe

MUSICAL INSTRUMENTS

THIS IS ONE UNUSUAL SYNTH KIT.

PHANTASTRON SYNTHESIZER KIT

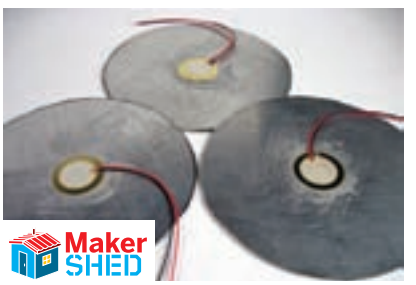
Electric Western $195
electricwestern.com

Complexity	5
Components	5
Documentation	4
Community	1
Completeness	5

In an alternate Old West universe, folks played synthesizers, and they called 'em "Phantastrons." Incorporating tubes, steel panels, and a branded wooden crate ripe for customization, this is one unusual synth kit. The power supply comes mostly assembled, but the 30s-era "turret board" is a challenge for seasoned solderers. Not your standard volt-per-octave functionality; this oscillator beast can be steered via amplified audio, or control-voltage signals, reacting with a rebellious voice. Plus, the onboard controls and rotary selector offer three waveforms to tweak pitch. Though it would be a welcome addition to my "guitarsenal," I foresee using this as the core of an unusual instrument.

–Collin Cunningham

TURN ANYTHING INTO A DRUM SET.



DRUM KIT KIT

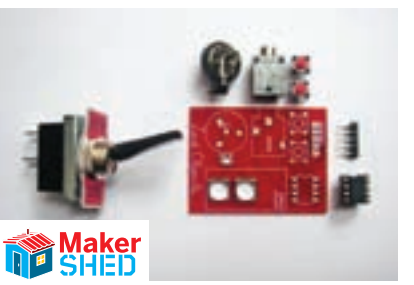
Spikenzie Labs $19
makershed.com MKSKL2

Complexity	2
Components	5
Documentation	4
Community	3
Completeness	3

Turn anything into a drum set with your Arduino and this simple kit. Some makers build custom drum sets from fine hardwoods, while others take the easy route and make practice sets from mouse pads and sheet metal. Instead of building my own, I used the included piezo elements to trick out my Rock Band drums, hooked them up to my friend's Yamahas, and gave him a few more drumheads to tap. With software like GarageBand or Ableton Live, you can start making music right away. Simply map your notes with the Arduino sketch, and start recording.

–Jake Spurlock

PLUG IN YOUR HEADPHONES AND GLITCH OUT.



LOUD OBJECTS NOISE TOY

Loud Objects $20
makershed.com MKLOK

Complexity	3
Components	4
Documentation	4
Community	3
Completeness	4

Bzzzzrrrreeeeepehkhkhkhhhhhhk! Build your own Noise Toy with this kit from electronic noise group the Loud Objects. Plug in your headphones and glitch out, or jack into an amp and play it as an instrument.

These kits come complete with a custom-printed circuit board, a noise generating microchip programmed with the firmware Loud Objects uses for their live performances, two buttons for modulating the sound, headphone jack, and battery.

MOST DANGEROUS KITS

MOST KITS ARE SAFE WHEN USED RESPONSIBLY AS PART OF A BALANCED LIFESTYLE. HERE ARE A FEW OF THE OTHER ONES.

» Information Unlimited calls its kit-buildable **Burning Laser Ray Gun** ($1,576) an "excellent demonstration of future weapons technology. ... When used with a simple lens this laser can cut through a rock. When used with a lens system, the air will actually explode at the focus point." amazing1.com

» **The Firebird** ($3,295 base, $6,691 loaded) is the world's fastest R/C kit plane, clocked at 337mph. It's a needle-nosed mini gas turbine jet over 7 feet long with an 81" wingspan. jetmodelproducts.com

» Mile Hi Distilling's **Reflux Distiller Kit**, 13 Gallon Milk Can with 3" Torpedo Tower ($629), produces 180-proof spirits at a rate of 1 gallon per hour. That's a party. milehidistilling.com

» Brooklyn's Madagascar Institute teaches how to build a **Propane Flame Cannon**. madagascarinstitute.com

» Earth's Tongue sells **mushroom grow kits** "intended for edible gourmet mushroom cultivation" ($59) and spore samples of psilocybin mushrooms "intended for microscopy study" ($18–$38). earthstongue.com

» Gun laws restrict the sale of kits for assembling modern guns, but not front-loading black powder weapons. Cabelas sells the **Trapper .50 Caliber Pistol Kit** ($270), **Kentucky Rifle Kit** ($300), and many Civil War-era muskets. cabelas.com

» Information Unlimited's **High Power Large Tesla Coil** stands 8 feet tall and throws high-voltage electrical discharges 10 feet ($9,500 assembled, $7,000 kit, $20 plans). amazing1.com

» **BASE jumping rigs** (for parachuting from skyscrapers, cliffs, bridges, etc.) from Morpheus Technologies include a canopy or parachute, container, and optional wing suit (starting at about $2,000). baserigs.com

» Spud Gun Extreme sells **potato cannons,** both pneumatic and combustion-fired ($150 and $180), that can shoot potato plugs hundreds of yards. spudgunextreme.com

» RoadsideImports LLC sells **switchblade kits** like the Mikov Automatic ($80–$200) and 13" AKC Dark Horn Italian Stiletto ($125 and up). They sell many other switchblade, stiletto, and butterfly knives; just add the $16 "Make My Knife a Kit" option to avoid import failure. assistedknife.com

» Finally, the **DIY-X Explosive Simulants Kit** from Tactical5, which is used for training security personnel, isn't dangerous itself — but don't try carrying it through airport security. tactical5.com

iStockphoto/Evgeniya Moroz