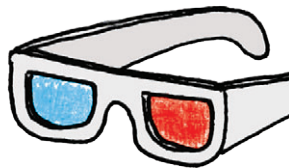


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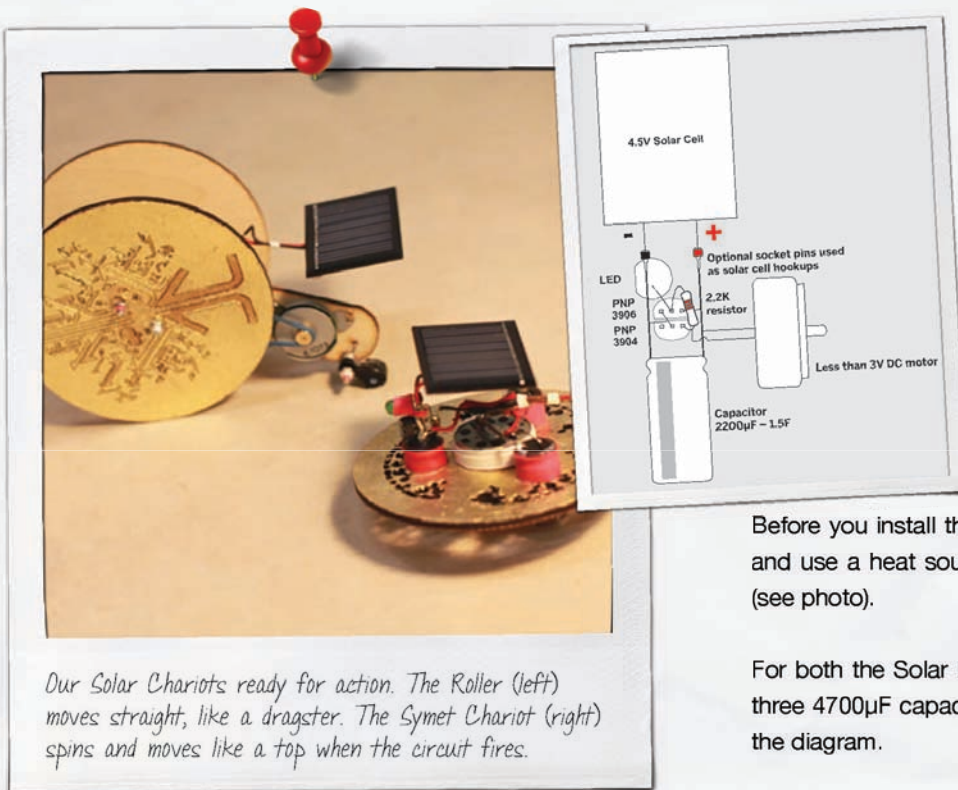
# CREATE SOLAR CHARIOTS THAT RACE WITH THE SUN

Use a simple circuit, DC motors, and solar cells to build autonomous racers.

BEAM (biology, electronics, aesthetics, mechanics) is a type of robotic design that makes use of simple components and bits of techno-junk to create cool robo-critters, many of them inspired by nature. Clever circuit designs, analog parts, and minimal components make it a perfect type of robot-building for beginners and kids.

## Let's Get Started:

The list below includes enough parts to make two solar engines. To assemble each one, follow the diagram and wire together all components as shown. Note that the flat sides of the transistors face each other. (You can use heat-shrink tubing to hold them together.)



*Our Solar Chariots ready for action. The Roller (left) moves straight, like a dragster. The Symet Chariot (right) spins and moves like a top when the circuit fires.*

This type of solar engine is called a FLED-type, for "flashing LED." The LED is not used as a light, but as a trigger to dump the charge from our capacitors. When the charge is high enough to flash the LED, it becomes a conductor and allows the current to flow through the circuit and turn the motor. When the charge is dissipated, the resistance goes back up and the charging phase begins again.

Before you install the LED, cover it with heat-shrink tubing and use a heat source to fix it onto the dome of the light (see photo).

For both the Solar Roller and Symet, you'll want to attach three 4700µF capacitors (in parallel) where one is shown in the diagram.

One of the basic BEAM circuits is called the Solar Engine, a simple means of collecting a solar cell's output and using it to power a motor. The Solar Engine can be used to drive all sorts of BEAMbots. In this project we'll use it as the muscle to power a little solar race car and a top-like spinner.

Once the circuit is built, the real creative fun comes in with laser cutting (or using another cutting method) the structural components and wheels for your vehicles. We have downloadable templates available on the Make: Projects page at [makeprojects.com/project/b/1939](http://makeprojects.com/project/b/1939). When you're done assembling the parts from the template,





Once you have the circuit working, try using higher-value capacitors (such as "supercaps"). Try different bodies for the Roller. See if you can increase your circuit firing time/distance traveled. BEAM is all about learning through trial and error. Experiment!

you can attach the circuit to your motor and the solar cell to your circuit. (Again, see the project online for details.)

Now take your racers into the sunlight and start your engines! The Symet will spin and move when it releases its charge, and the Roller will race forward like a solar-power dragster. For maximum racing fun, build two Symets or two Rollers and race against your friends.

By Gareth Branwyn, MAKE Editorial Director, and Zach and Kim DeBord

## PARTS

- ☐ (2) Transistor 2N3904 ('3904') NPN #276-2016
- ☐ (2) Transistor 2N3906 PNP #276-1604
- ☐ (2) Flashing LEDs #276-036
- ☐ (2) 1/4W 2.2K resistor #271-1325
- ☐ (6) 4700uF capacitors #55047495
- ☐ (2) 4.5V solar cell
- ☐ (2) DC motors (salvaged from portable cassette player)
- ☐ (4) Socket pins
- ☐ Heat-shrink tubing
- ☐ Hex nuts
- ☐ Machine screws
- ☐ 1/8" telescoping metal tube

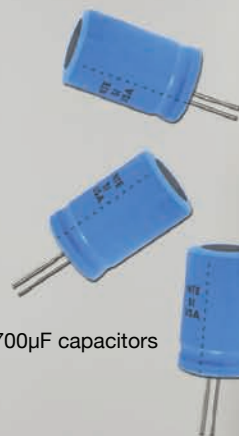
## SOLAR CHARIOTS INCLUDE THESE RadioShack PARTS



Heat-shrink tubing



Flashing LEDs



4700uF capacitors



Transistors 2N3904 - 2N3906

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



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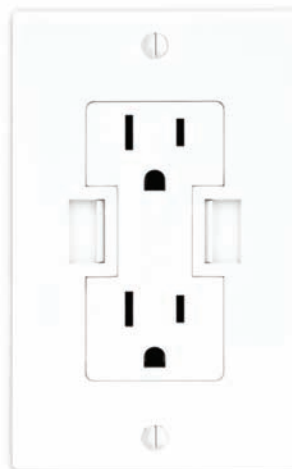
You typically have two options for charging these devices:

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PAGE 16



## SUMMER PROJECTS



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- |                                                   |                                                       |
|---------------------------------------------------|-------------------------------------------------------|
| <b>18</b> <b>School's Out!</b><br>A Summer of Fun | <b>56</b> <b>Pranks</b><br>Super TV-B-Gone            |
| <b>20</b> <b>Combat</b><br>Marshmallow Shooter    | <b>64</b> <b>Flight</b><br>Compressed Air Rockets     |
| <b>26</b> <b>Outdoors</b><br>Backyard Zip Line    | <b>72</b> <b>Electronics</b><br>Print Your Head in 3D |
| <b>32</b> <b>Rainy Day</b><br>Frozen Banana Pops  | <b>80</b> <b>Weird Science</b><br>Kryptonite Kandy    |
| <b>38</b> <b>Craft</b><br>Silk-screen T-Shirts    | <b>86</b> Send us your <b>Summer of Making</b> Video  |
| <b>46</b> <b>Music</b><br>Cigar Box Guitar        |                                                       |

- 6** Welcome to a Summer of Making
- 8** How We Made This Issue 3D
- 10** Making Big Things in 3D
- 14** 3D Photos and Video on a Shoestring
- 17** Scavenge Your Neighborhood



## YOUNG MAKERS

- 88** Ben Hylak: How Maker Faire Changed My Life
- 90** Sylvia Todd: Also Known As Super Awesome Sylvia
- 91** Marc-Charles Morquette: Future Robotics Engineer
- 92** Brian Conway: Ballistics Boss
- 93** Joey Hudy: Federal Marshmallow Czar
- 94** Andrew Katz: Arduino Automator
- 95** Schuyler St. Leger: 3D Fab Fanatic



## AND MORE

- 98** I-Wei Huang's Advice for Young Makers
- 100** Making More Makers in "Project Make"
- 104** Expert Tips for Making with Kids
- 108** Tools & Toys: Reviews for Kids, by Kids
- 112** Howtoons: Summer Games



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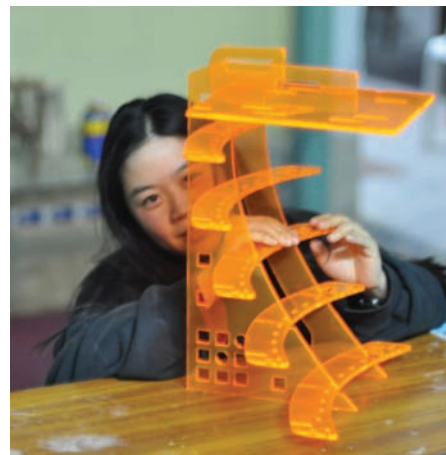


# Learning by Making.

Ed Wall, a technology teacher in Elmira, New York, has been in classrooms for more than a quarter of a century. Says Ed, "the key to success is to spark an interest by making the learning process engaging and fun."

"Making things is the key! For example, our science and math teachers work together to teach geometrical principles, by having students design and build an octagonal desk set."

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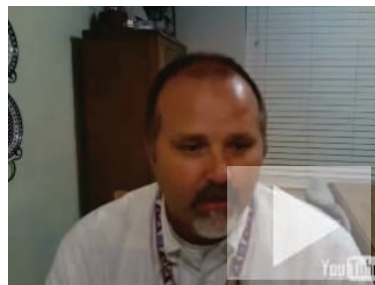
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# A SUMMER OF MAKING

BY DALE DOUGHERTY

Dale Dougherty with the Project Make class  
(see page 100 for more about the program).



When I recently visited a middle school in Santa Rosa, Calif., I saw no students. None. I learned it was the week for standardized testing. The library and playground were empty.

The school was designed for 1,100 students and now serves only 300; 85% of them are low income. If parents can afford it, they apply for a transfer to a better school. These are the children left behind.

Previously, I met with the school board and superintendent to talk about ways to introduce making into schools. An assistant superintendent suggested that this middle school was a good place to start, and that we could make a difference by starting with a maker-themed summer camp, working with the local Boys & Girls Club.

For all kids, time spent outside of school is as important, if not more so, than time inside school. Some kids have perfect summers filled with engaging activities and family trips. They even get to spend weeks at incredible summer camps. Other kids aren't so lucky and don't have enough to do. Experts believe that summer is a period when disadvantaged kids give up some of the gains made during the school year. They start the next year behind.

Back at the deserted school, the principal gave us a tour to find a space for the summer camp. She showed us a few uninspiring class-

rooms with no windows; a science lab that doubled as a Spanish classroom; a music room no longer in use, even though old instruments were in view. We found a room that read "Wood Shop" on the door, but I stepped inside to find exercise equipment for phys ed class. The next room said "Metal Shop" and was mostly empty, except for a storage area with some old machines still hanging around.

I knew right away this would be a perfect space for kids. The Boys & Girls Club director asked if we could paint the room. "You can do anything you want," the principal said. Excellent, I thought, a project for the kids. She encouraged us to create a makerspace that could be used not just this summer, but during the school year too. "These kids need it," she explained. "They need to play. They need opportunities to create."

As we talked about the program, I warned everyone that it could be messy — we didn't necessarily know everything but I was pretty sure the kids would have a lot of fun. I recalled the silk-screening project in our lab and suggested that the summer camp could start off by inviting the kids to make their own camp T-shirts.

"I'm so happy you care about this school and its kids," the principal said. It was her birthday, and she said she would consider the summer camp a birthday present.

When I returned to our office, I saw galleys of this "Best Summer Ever" issue, our first devoted to kids. I realized we had already done a lot of the hard work of selecting great projects for kids. The timing was perfect, I thought. We'll use it as a guide for the summer camp.

Later the same day, I was on a call with this issue's cover girl, Super Awesome Sylvia, and her dad. I told her about the summer camp and asked if she'd visit and do some fun projects with the kids. They'll have seen her on the cover, so I'm sure it would mean a lot to them to meet her. Sylvia's father said she was beaming. So was I.

This special issue provides all you need for a summer of making in your own community. Just add kids, even some who aren't yours. It's going to be a bit messy but lots of fun. Send me some pictures or a video (page 86). Extra credit for 3D.

Dale Dougherty is founder and publisher of MAKE.

Gregory Hayes



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# HOW WE MADE THIS ISSUE 3D

MAKING THE DIFFERENT FLAVORS OF OUR “SCHOOL’S OUT” 3D IMAGES. BY PAUL SPINRAD



When the MAKE staff was first exploring a 3D issue, we planned to do the whole thing using 2D-to-3D image conversion, with the help of industry leader 3DX (see right). But our Maker-in-Chief Sherry Huss had the brilliant idea to also reach out to the vibrant maker community and immediately thought of Maker Faire alumnus Barry Rothstein (pictured). Barry happily agreed to come to our headquarters in Sebastopol, Calif., and he led us in a fun 3D photo shoot surrounded by a bunch of cool projects, tons of kids, a few dogs, and only a little poison oak — it was the only downer of the weekend!

Using a rig of his own making, Barry shot these images with his twin Sony DSC-R1 cameras synchronized with a LANC Shepherd trigger controller. He produced most of the photos as *traditional 3D images*, where the depth appears behind the picture plane. But the inset photos of the marshmallow shooters (page 21), frozen banana pops (page 33), TV-B-Gone (page 57), rockets (page 65), Ella’s 3D-printed head

(page 73), and Kryptonite Kandy (page 81) are all *phantograms*, where the subject appears closer than the picture plane, rather than behind it.

When Barry was getting started with 3D, he used a modern replica stereoscope and shot his photos using the “cha cha cha” method (aka the “stereo shuffle,” described on page 14). Later he learned how to make phantograms. To align the stereo pairs more accurately and improve 3D quality, he built a tripod-mountable slider bar for his camera out of sliding aluminum door parts, which he used to produce his first book, *Phantograms from Nature*.

Creating phantograms is easy — look for a PDF tutorial on Barry’s website ([3ddigitalphoto.com](http://3ddigitalphoto.com)). Before snapping your picture, you place a rectangular frame, just like a wooden picture frame, around your subject. Once you’ve got your shots, you do some simple Photoshop work to crop them and then run them through StereoPhoto Maker or other anaglyph software.

If you make your own phantograms, submit them on Barry’s



Barry Rothstein at our 3D photo shoot for this special issue.



**3DX**  
EXPERIENCE YOUR BRAND

MAKE produced the image on this cover a different way. Photo Editor Gregory Hayes took a 2D photo of Super Awesome Sylvia, and we sent it to 3DX ([go3dx.com](http://go3dx.com)), a company that performs 2D-to-3D image conversions for print and movies. Using proprietary software that interprets the depth cues from a 2D image, they construct a simulation of the original 3D scene. If you’ve been to the movie theater lately, you’ve probably seen one of their cool posters!

website, and he’ll post them up for the world of 3D enthusiasts to enjoy.

MAKE Executive Editor Paul Spinrad can move his eyeballs apart to view stereo pairs without a stereoscope (but not while keeping them in focus).



# You Could Win Big.



**Take the MAKE survey for a chance to win  
a \$150 Maker Shed gift certificate!**

With our first issue devoted to projects for  
the whole family, we want to hear from you  
about how we can make MAKE even better!

**Tell us what you want to make!**

## **Make:**

[makezine.com/tellus/survey](http://makezine.com/tellus/survey)

No purchase necessary. Sweepstakes starts 5/19/12 and ends 12/31/12.  
Must be US legal resident, 13 years and over. Visit our survey site for entry, rules, and more information



# MAKING BIG THINGS IN 3D



GOT CARDBOARD? BUILD BIG 3D OBJECTS FROM 2D “SLICES.” BY SAUL GRIFFITH WITH SAM CALISCH

Autodesk and Otherlab teamed up to create 123D Make ([123dapp.com/make](http://123dapp.com/make)), a “decomposition” application for building cool stuff out of 2D shapes, or “slices.” These instructions will work for any 3D model, but my 3-year-old loves *T. rex*.

In this article I’ll show how you can use these clever algorithms, automatically generated instructions, and low-cost materials to make just about anything, and then make it big.

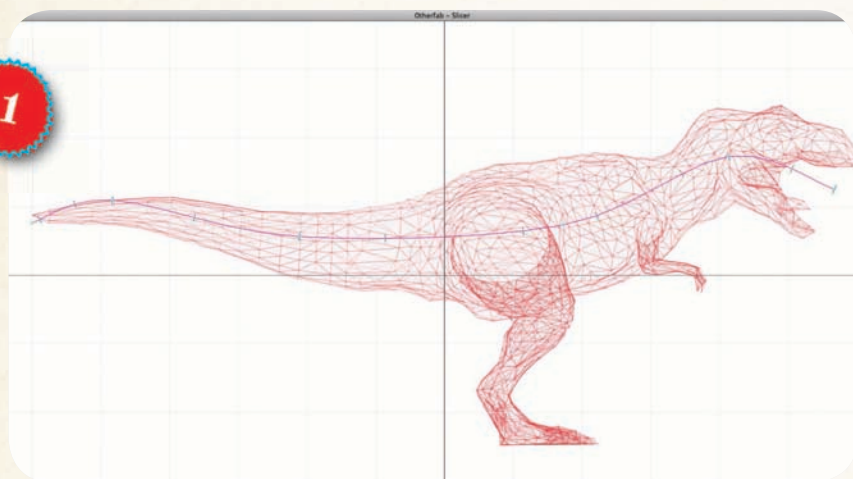
## 1. FIND, MIX, OR MAKE A 3D MESH

There are great free 3D models all over the web, and they’re multiplying fast. Try TurboSquid ([turbosquid.com](http://turbosquid.com)) or Google 3D Warehouse ([sketchup.google.com/3dwarehouse](http://sketchup.google.com/3dwarehouse)) for a start. Download your model as an STL file.

For bonus points, modify your mesh using MeshMixer ([meshmixer.com](http://meshmixer.com), see page 76 for more about it) or create your own mesh with AutoCAD or Rhino.

The wealth of models available is great, but they often have small errors, invisible to the eye, that throw off the math required to slice and dice them. Don’t worry if your mesh isn’t “watertight” — 123D Make has some very slick tools that automatically fix holes, self-intersections, and other errors. It’s Eulerian magic!

1



3D printing is exciting and has the maker world all aflutter. It is wonderful, but it’s still not a technology that can produce big models quickly, from robust materials, at a low cost.

At my company, Otherlab, we’ve been working with Autodesk on several very lightweight, very fun software tools to quickly break down 3D models into physical parts and assembly instructions. The result: you can quickly build your model at any scale, from a great variety of materials. It’s a brain-twisting jigsaw

puzzle with the ultimate payoff: your geometry, made real big, in real stuff.

For example, imagine you need a dinosaur to complete your Halloween costume — a *Tyrannosaurus rex* that’s actually rideable (for a very lucky 3-year-old). How are you going to make a truly awe-inspiring dino before your fast-approaching party?



## 2. SLICE IT

Create a free account at [123dapp.com](https://123dapp.com) and then open the 123D Make web app. Choose your construction technique: Stacked Cardboard Slices. (You could also choose the Folded Paper Panels technique to make an origami-like model.)

Now upload your model as an STL file. 123D Make will automatically heal any errors in the mesh, and then turn your model into horizontal cardboard slices!

Click on the Model Setup tab and you can change the size of your model. The web app currently allows you to design a 12"-tall model, which is a lot bigger than most 3D printers (see Step 3 to go even bigger).

You can also choose to slice your model using planes that are parallel across one of the 3 radial axes:

- » x axis (vertical slices, side to side)
- » y axis (vertical slices, front to back)
- » z axis (horizontal slices).

These planes may vary depending on the model you use. For a stronger *T. rex*, click on Edit Plane Direction, and select the plane that makes vertical slices, lengthwise (nose to tail), as shown here.

## 3. MAKE IT EVEN BIGGER (OPTIONAL)

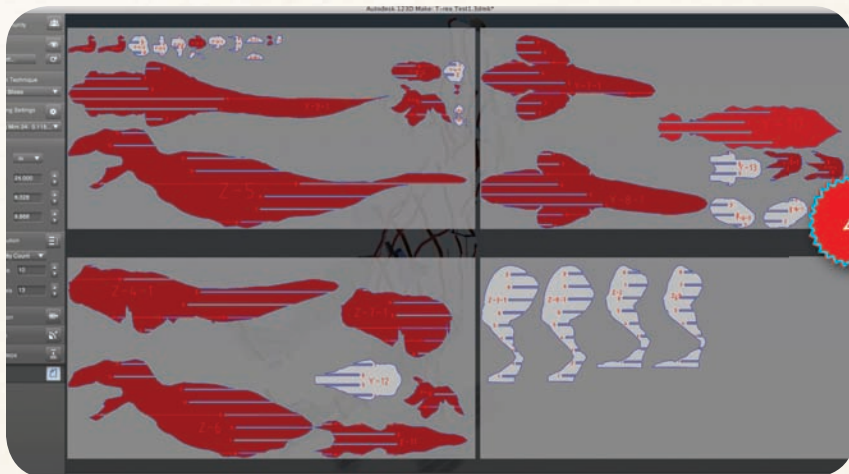
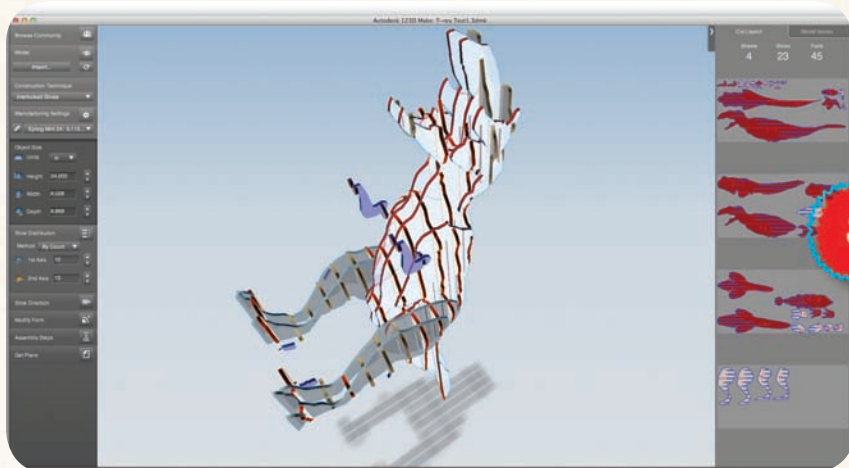
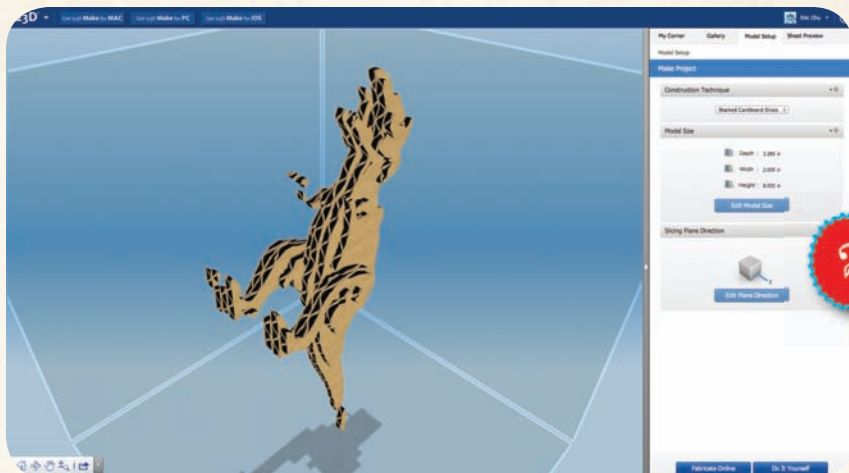
Remember, we're going big here. To make a model taller than 12", you'll need to download the desktop version of 123D Make (free for Mac or PC), which can scale your model up to any size!

Another nice feature of the desktop version: instead of just slicing on the x, y, or z plane, you can position your slices along an arbitrary path (the backbone itself), creating a cool "skeletal" structure. Or choose the Interlocked Slices technique to make a "waffled" model, as shown here.

## 4. CUT OUT YOUR SLICES

After slicing up your dino, you'll have a set of output shapes or slices. You can see these under the Sheet Preview tab. Now you need to cut them out. Here are 3 ways:

- » If you're lucky enough to have



access to a laser cutter, they're almost as easy to use as an inkjet printer. Change the Sheet Size to something the laser cutter can handle, and then click Do It Yourself to download the patterns for all your slices. These EPS files can be sent directly to a laser cutter by Adobe Illustrator, Corel Draw, or almost

any program that can read and print EPS files.

» If you don't have a laser cutter handy, you can click Fabricate Online, and Autodesk will laser-cut your cardboard parts and mail them to you for about \$10. Or you can send your files to a service like Ponoko ([ponoko.com](https://ponoko.com)) to cut them out and



mail them to you.

» For the patient maker, a printer, tape, and an X-Acto knife will get the job done. Set the Sheet Size to something your printer can handle, and then click Do It Yourself to download the patterns for your slices. Print them full-size on paper, tape them to cardboard, and cut the shapes out carefully.

## 5. ASSEMBLE YOUR MODEL

This is the fun part. These sliced models have all the brain-twisting fun of a puzzle — in 3D. Stack and glue them in numerical order, or if you used more complicated slicing paths, slide the notches together. Watch your model take substance.

## 6. SKIN IT IN PAPIER-MÂCHÉ

Using your sliced model as a support structure, it's easy to make a skin with papier-mâché. Start with a few cups of warm water and mix in all-purpose flour a cup at a time until the mixture is thick enough to hang on your fingers.

Tear long strips of newspaper, dip them, and wipe off the flour-water mixture, leaving them covered with a thin layer. Apply the strips in a cross-hatched pattern, but avoid building up too many layers at once.

After several layers, the papier-mâché should be strong and tough.



To help coats dry faster, apply strips of dry newspaper with heavy pressure in particularly wet areas.

For the last coat, mix some wood glue into your mixture for a smoother finish.

## 7. APPLY PAINT AND PERSONALITY

Papier-mâché takes paint well. Get creative and give your *T. rex* some style. If you want to get crazy, you can get some amazing effects with sanding and painting (see [ultimatepapermache.com](http://ultimatepapermache.com)). Don't stop at painting — add feathers, claws, horns, and laser-beam eyes.



## 8. MAKE ONE EVEN TOUGHER AND BIGGER

Cardboard is cheap and easy to cut, but other materials can make bigger, stronger stuff. Lasers can cut wood, acrylic, steel, matte board, and tons of other materials, but don't be afraid to tackle this project with a good old-fashioned router or band saw (with adult supervision).

This technique is great for school plays, parade floats, human-sized chess sets, or any other time small just won't do.

Saul Griffith is chief troublemaker at Otherlab ([otherlab.com](http://otherlab.com)). Sam Calisch, also of Otherlab, makes math make things.

Sam Calisch





# 3 Billion Devices Run Java

Computers, Printers, Routers, BlackBerry Smartphones, Cell Phones, Kindle E-Readers, Parking Meters, Vehicle Diagnostic Systems, On-Board Computer Systems, Smart Grid Meters, Lottery Systems, Airplane Systems, ATMs, Government IDs, Public Transportation Passes, Credit Cards, VoIP Phones, Livescribe Smartpens, MRIs, CT Scanners, Robots, Home Security Systems, TVs, Cable Boxes, PlayStation Consoles, Blu-ray Disc Players...

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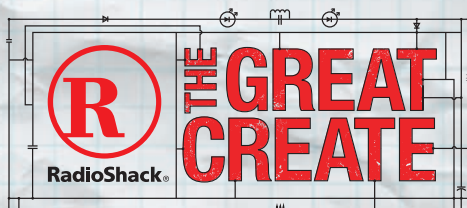
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[oracle.com/goto/java](http://oracle.com/goto/java)

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# RED LEFT, BLUE RIGHT

MAKE 3D MOVIES AND PHOTOS ON  
A SHOESTRING. BY STEVE WHITE

Want to make your own low-budget *Avatar*?

3D video camcorders and displays are getting cheaper, but they're still fairly expensive, and the only sub-\$100 cameras that take 3D still photos all use roll film. So I thought it would be fun to mix the old with the new and see how cheaply I could build a digital camera rig for creating old-school red-blue 3D stills and video.

My design goals included real-time preview ability, focus and parallax control, and perhaps most importantly, compatibility with my daughter's *Barbie and the Magic of Pegasus* 3D glasses.

Good old red-blue anaglyphic 3D works on ordinary screens, can be printed using any color printer, and requires only super-cheap glasses for viewing. You can't do all that with the polarization-based 3D that movies use today. And there's free, easy-to-use software that lets you create anaglyphic 3D from stills and video captured with ordinary digital cameras. Looking at 3D is fun, and it's even more fun when you've shot it yourself.

## THE STEREO SHUFFLE

The easiest way to start making your

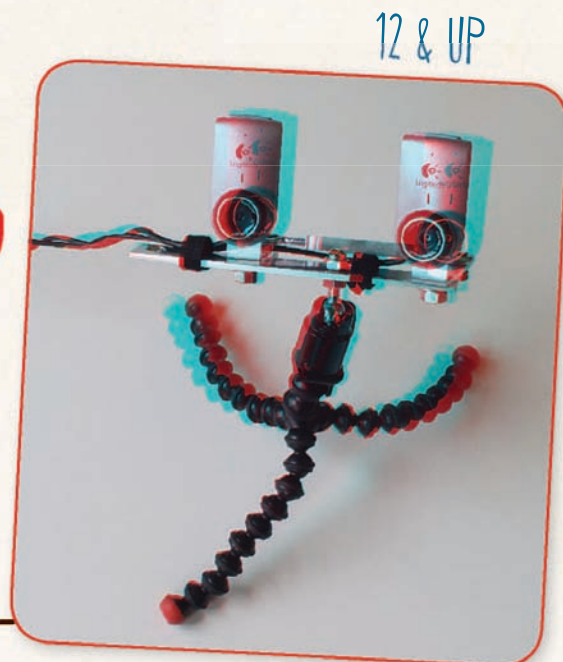
own 3D photos is the *stereo shuffle*, described by Bill Coderre in MAKE Volume 06 (page 143).

Take your digital camera outside and find a scene with a fun variety of distances to focus on. The closest objects should be at least 5 feet away, and perfectly still. Also, make sure that everything in the scene will be in sharp focus. Sunny conditions will help your depth of field.

Ready? Hold the camera to your eye, and lean very slightly to the left. Snap a picture. Lean very slightly to the right, and snap another picture. That's your basic *stereo shuffle* right there.

Avoid scenes where there's a lot of movement, because you capture the 2 images at slightly different times. And as with all images that are destined for red-blue anaglyphic, whether stills or video, avoid subjects that are red or pink, or have vertical stripes. (Zebra stripes make perceiving depth with binocular vision more difficult, a feature which helps protect zebras from predators, especially when they're clustered together and running.)

Another fun source of 3D stereo pairs is any 2D movie that you can watch on your computer screen. Grab 2 frames from any horizontal tracking shot, and use them to create a 3D scene.



## TWIN CAMERA STILL PHOTOS

To take high-quality 3D photos, you need 2 camera lenses capturing the image at the same time, either on a special 3D camera (the non-film ones are expensive) or on 2 regular cameras that you synchronize.

For high-end still cameras, you can find twin camera controller plans and products at the Ledamatrix Digital Stereo Photography website ([ledamatrix.com](http://ledamatrix.com)).

## ANAGLYPH PHOTO SOFTWARE

You can use free software to create a red-blue anaglyph out of 2 images, such as StereoPhoto Maker ([stereo.jpn.org/eng/stphmkr](http://stereo.jpn.org/eng/stphmkr)), which is Windows-only, and Anabuilder ([Anabuilder.free.fr/welcomeEN.html](http://Anabuilder.free.fr/welcomeEN.html)), which runs cross-platform. These programs remove red tones from the right image, remove green and blue (cyan) tones from the left image, and combine them into a 3D image that you view with red-cyan 3D glasses. Parts of the image that appear dark to the left eye and light to the right will look cyan, and areas that look light to the left eye and dark to the right will look reddish.

StereoPhoto Maker aligns the left and right photos into a combined stereo anaglyph automatically and can generate them in batches.

With AnaBuilder, you need to align



## MATERIALS & TOOLS

LOGITECH 960-000043 QUICKCAM DELUXE WEBCAMS (2) I bought these refurbished for \$15 each. This is a good webcam for this project due to its small size and focusable lens.

RIGHT ANGLE BRACKETS, 2" (2)

MENDING PLATE, 6", METAL with 4 mounting holes

TURNBUCKLE,  $\frac{3}{16}$ "  $\times$   $5\frac{1}{2}$ ",  $2\frac{1}{2}$ " TAKE-UP

HOT SHOE MOUNT/TILT ATTACHMENT FOR CAMERA such as the ePhoto Adjustable Swivel Hot Shoe Mount FT9712H, available from Amazon

MINI TRIPOD such as the GorillaPod Magnetic, #MKJB01 from Maker Shed ([makershed.com](http://makershed.com))

MACHINE SCREWS,  $\frac{1}{4}$ -20,  $\frac{1}{2}$ " LONG (2 FLAT-HEAD AND 2 ROUND-HEAD)

NUTS,  $\frac{1}{4}$ -20 (5)

WASHERS,  $\frac{1}{4}$ -20 (4)

ACORN NUT,  $\frac{1}{4}$ -20

CONTACT CEMENT

LAPTOP COMPUTER WITH 2 FREE USB PORTS, WINDOWS-BASED

3D CAPTURE SOFTWARE such as Stereoscopic Multiplexer and Player ([3d.tv.at](http://3d.tv.at)) or Onuprova 3D Camera ([redcyan3d.codeplex.com](http://redcyan3d.codeplex.com)), depending on whether you're making video or stills

3D GLASSES, RED-BLUE ANAGLYPHIC like the ones bound into this magazine

USB EXTENSION CABLES (2) (OPTIONAL)

The webcam cables are a bit short.

SCREWDRIVERS, PHILLIPS HEAD (2) one small, one large



each image pair manually. Using the arrow controls, you move, stretch, and rotate the left image against the right, so that all objects align horizontally, and the closest point on the nearest object has its 2 views superimposed. This puts it at "window depth," which is easier to view. You can experiment with "eye poking" 3D, such as phantagrams, later.

## HARDWARE AND SOFTWARE FOR 3D STILLS AND VIDEO

For video and lower-resolution stills, an easier hardware setup is a Windows laptop with 2 USB webcams plugged in. You can shoot and produce 3D video using Peter Wimmer's Stereoscopic Multiplexer and Stereoscopic Player software (free trial version at [3d.tv.at](http://3d.tv.at); register for full functionality and to remove watermarks), or you can capture and produce 3D stills using the free Onuprova 3D Camera software ([redcyan3d.codeplex.com](http://redcyan3d.codeplex.com)).

With a webcam-laptop setup, you need to keep the 2 webcams securely positioned and lined up precisely. Here's how I put together a fun and easy 3D capture rig for around \$35. As a first-time maker, I'm proud to introduce the Frankencam3D.



## BUILD THE FRANKENCAM3D

**1.** To remove the clamp on each webcam, unscrew the 3 screws in back. Lift away the back cover and gently unplug the USB cable's connector



from the circuit board. Remove the 2 screws that hold the cable clip and slide it away to separate it and the cable from the back cover. Pop the clip off the back cover by pressing the cover against a flat surface.

**2.** Mount the brackets to the back covers with contact cement, aligning them by positioning the upper edge of the metal where the bevel for the cable starts. The cover's straight sides make a nice guide for vertical alignment, and a hole in each bracket allows access to the lower mounting screw. (I returned the screw to its hole before this step to make reassembly easier.)

Replace the USB cables on both camera covers, plug the cables into the circuit boards, and screw the covers back onto the cameras.

**3.** Mount the camera brackets to the mending plate using the plate's first and third holes (shown on page 16). This approximates the distance between your eyes, for a realistic 3D effect. Then link the back ends of the camera brackets with the turnbuckle, using the flat-head screws.

**4.** Unscrew the top and bottom parts of the hot shoe mount so that you're left with only the pivot joint. Screw this joint onto the tripod, screw a nut on top, then fit the camera rig over the nut and secure it with the acorn nut. Finally, hook up the USB cables to your laptop. That's it — the rig is ready to go.



The Logitech cameras include a velcro wrap on the USB cables, which you can use to neatly manage the rig's wires. The turnbuckle in back lets you experiment with the rig's parallax control, fine-tuning the cameras' angles to achieve more precise 3D effects.

## MAKING 3D MOVIES

**5.** To capture and produce 3D video with Stereoscopic Multiplexer, first select the 2 USB cameras in the configuration wizard under the Driver menu. The software will display the live webcam feeds side-by-side; make sure the order is correct (left and right), then turn the camera lenses to manually focus each one. Close Stereoscopic Multiplexer.

**6.** Open Stereoscopic Player and select File → Live Playback/Stereoscopic Multiplexer to display your live stereo image. Under Settings, choose the Optimized Anaglyph Red-Cyan playback option, and test the image with your 3D glasses. Now you can compose your shot, readjust the focus if needed, and experiment with the parallax to see what works best.

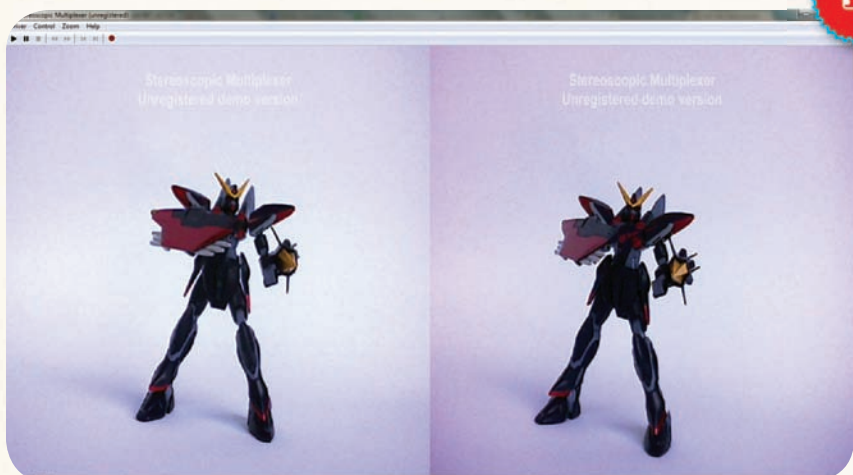
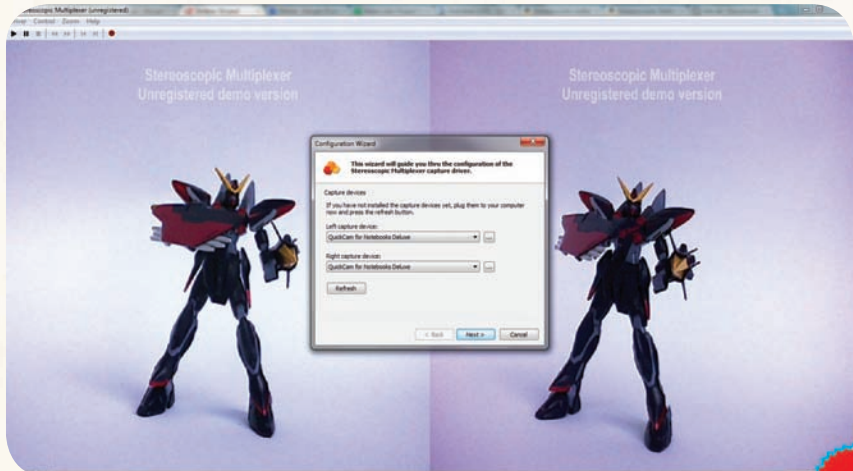
When you're satisfied with the image, close Player and relaunch Multiplexer. Now you can record video clips by clicking the Record and Stop buttons. You can view your clips back in Stereoscopic Player, in a number of 3D video formats.

Onuprova 3D Camera works basically the same way, and also has a shutter button for capturing 3D stills.

That's it. You're now officially a 3D photographer or moviemaker! Many factors will impact your results, including distance from the lens, severity of parallax, focus, and lighting. So start experimenting, and by all means, find ways to improve your rig.

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Steve White ([stevewhiteproductions.blogspot.com](http://stevewhiteproductions.blogspot.com)) is a filmmaker, writer, and twin dad living in Asheville, N.C. He produced and directed the feature film *Immortal* and wrote *VisionFactory: Adventures in Corporate Screenwriting*. He's currently working on a new book *One and a Half Stars on Netflix*, and the screenplay *KITTEH!*





# SCAVENGE YOUR NEIGHBORHOOD!

LOOK AROUND! YOUR NEIGHBORHOOD CAN BE A TREASURE TROVE OF GREAT MATERIALS AND TOOLS FOR MAKING.

## CURBSIDE FREEBIES

Even though some of it can be tricky to snag when you're out on your bike, you'll want to find a way to carry the occasional piece of lumber or discarded electronics back to your home base.

## CONSTRUCTION SITE

No need to hop the fence after hours — the site foreman will gladly unload unwanted lumber, foam board, and other random bits and pieces. Just ask nicely.

## GARAGE SALE

Need a hammer and some nails? How about someone's stash of practically new craft supplies? Just remember to haggle — these sellers are trying to get rid of their old junk, and they want you to take it away!

## THRIFT SHOP

Grab your coin jar and spend your pennies on how-to books, tools, and cheap electronic gadgetry. You'll find aisles and aisles of value.

## SURPLUS STORE

Where else are you gonna find a box of turbo-encabulators with pre-fabulated amulite, surmounted by a malleable logarithmic casing whose two spurving bearings are in a direct line with the pentametric fan? Only at Colonel Scratchy's Military and Scientific Junk Emporium!

## DUMPSTER

One man's trash is another man's treasure. Get permission from the owner before diving in for cardboard boxes and wooden pallets, and always keep a sharp eye out for rats and rusty nails. Yuck!





# SCHOOL'S OUT!



ROCK OUT!

It's June 1, and you and your pals are streaming out of class for the last time this school year, toting note-filled yearbooks and dreaming of all the fun you're going to have over the next three months. Summer is magic — it's when you can do what you want instead of having to do what teachers tell you to. No homework, no tests, no having to deal with classmates you don't like, and no memorizing irrelevant things that most of the adults you know forgot a long time ago (and that you can always look up anyway).

Nina, Ella, Josh, and his big brother, Leo, are neighbors who live in Sebastopol, Calif., and they're all thrilled that summer break is finally here. They don't know what they're going to do yet, but that's the point. They just know they want to have fun, and they want to MAKE it up as they go along. Let's join them! ➡





3-D



MAKE A  
MARSHMALLOW  
SHOOTER!



FLY THROUGH THE TREES  
WITH THE GREATEST  
OF EASE!











## SCHOOL'S OUT: **COMBAT**



After a year of (relative) obedience in class, it's time for some healthy combat. Nina, Josh, and Ella whipped up these amazingly effective marshmallow shooters in the morning, and took them to the park for an afternoon of sticky mayhem. After the battle, Josh showed off his ability to catch high-flying marshmallows in his mouth. Be warned: the 'mallows melt in the sun, and a park ranger might make you pick them out of the grass. ➡



# MARSHMALLOW SHOOTER

PVC-FUELED FOOD FIGHTING.

BY ERIC WILHELM

This marshmallow shooter will completely surprise you with its accuracy, range, and ease of construction. Plus, it's tons of fun, and a lot better than any store-bought toy because it encourages modifications.

## BUILD YOUR SHOOTER

**1.** On the PVC pipe, measure and mark one 6" length of pipe and five 4" lengths. Wrap a small piece of paper evenly around the pipe at each mark and use the paper's edge as a guide to mark the pipe all the way around.

**2.** Use a hacksaw to cut the pipe evenly along the marks you made. Hold the pipe in a vise during cutting, or clamp it to the edge of a table. Either way, it should be secured right next to the cut line. Cut with even strokes and slight pressure against the PVC.

**3.** Use a file or sandpaper to square the cut ends of the PVC, smooth away sharp edges, and remove burrs.

**4.** Lay out your pieces as shown in the plan and assemble them. Just press them together firmly. Friction should hold them all together.

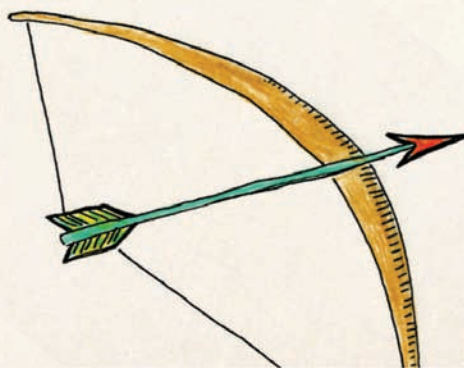
**5.** You can decorate the gun with permanent marker, duct tape, paint, or pretty much anything else that will stick to PVC.

## USE YOUR SHOOTER

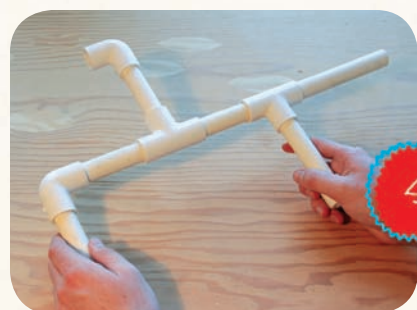
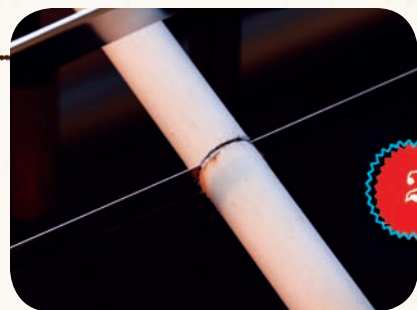
To use the gun, point it in a safe direction. Load one mini marshmallow at a time into the mouthpiece, and then seal your lips around it. To fire, blow as much air as you can in a short, sharp blast. Yes, the marshmallow does go around those curves. Pretty cool, huh?

Keep your ammunition sealed. Dried-up marshmallows don't work very well.

Clean up your marshmallows when you're done. Especially, don't leave any around roads: they'll attract animals, which might then be hit by cars.



ALL AGES  
ADULT SUPERVISION





## MATERIALS

Get the new MAKE Marshmallow Shooters Kit with enough ready-to-assemble parts to build 2 shooters (item #MSMMS at [makershed.com](http://makershed.com)), or buy your own pipe and fittings from the hardware store.

PVC PIPE,  $\frac{1}{2}$ " 26" LENGTH  
With PVC pipe and fittings, a nominal diameter of  $\frac{1}{2}$ " refers to its internal diameter (ID). The pipe's outer diameter is closer to  $\frac{7}{8}$ ", and the fittings are sized to fit around this.

PVC PIPE FITTINGS,  $\frac{1}{2}$ ":  
ELBOWS (2), TEES (2), END CAPS (2)

MINI MARSHMALLOWS

FOR SODA BOTTLE SAFETY GOGGLES:

SODA BOTTLE, 2 LITER  
ELASTIC BAND such as a large rubber band or a strip cut from an inner tube

## TOOLS

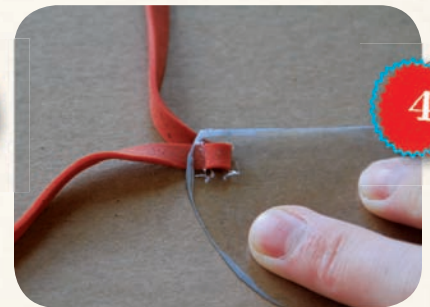
RULER  
PENCIL  
PAPER, SMALL PIECE  
HACKSAW  
VISE OR CLAMP  
FILE OR SANDPAPER, MEDIUM GRIT

FOR SODA BOTTLE SAFETY GOGGLES:

MARKER  
SCISSORS



This project previously appeared on Instructables ([instructables.com](http://instructables.com)) and Howtoons ([howtoons.com](http://howtoons.com)).



### SODA BOTTLE SAFETY GOGGLES

Mini marshmallows shot at high speeds can smack hard and even stick. These goggles will keep the fast-flying 'mallows from hitting your eyes and face.

**1.** Rip off the bottle's label, then cut off the top and bottom of the bottle.

**2.** Carefully cut down the middle of the bottle, to make it a sheet of plastic.

**3.** Wrap the sheet around your or someone else's face, and use a marker

to outline and design your mask.

**4.** Cut 2 slits in each corner of the mask, and weave each end of the elastic band through the slits, going out of the inner slit to the front side, then back in through the outer slit. Adjust your mask, and it's ready to wear.

Eric Wilhelm is the founder of Instructables and the director of communications at Autodesk. He has flown 75 feet in the air under a kite-powered contraption of his own design, and works from a homemade treadmill desk.





# SEE-THROUGH POTATO CANNON

12 & UP ADULT SUPERVISION

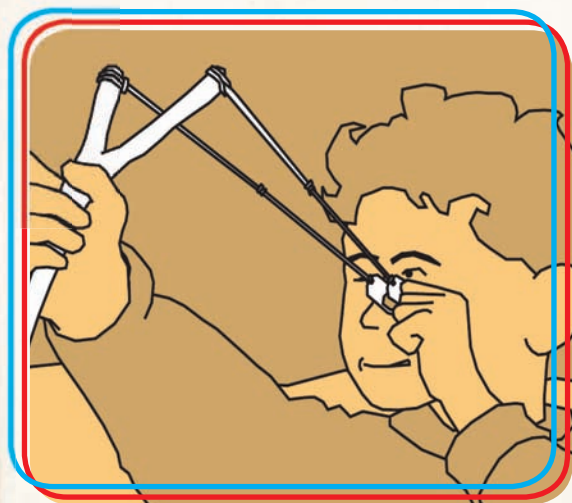
»» A mainstay for summer hijinks, the **potato cannon** is like the grenade launcher of any kid's arsenal. Get a firsthand view of exploding gases through the clear PVC, and develop your range-finding skills by experimenting with trajectory and combustive power.



## CHAINMAIL

ALL AGES

No brave knight embarks on a quest to save the kingdom without the proper protection. Use wire coat hangers and pliers to make basic patterns and create the chainmail armor of a true dragon slayer!



## SLINGSHOT

ALL AGES

Every kid worth his weight in trouble used to have a slingshot in his back pocket. You can make your own using household items. Practice your marksmanship on a row of soda cans or invent trick shots to impress your friends.



## PAWLONIA WOOD ARCHERY BOWS

12 & UP

Using inexpensive wooden blinds and some string, build a basic bow and master your archery skills. Experiment with tension: too loose and homemade arrows won't make it past your feet, but too tight and you'll need super strength to pull the string at all.



## ATLATL

12 & UP

This ancient hunting tool can hurl a 6-foot spear up to 100mph! Practice your woodworking skills and discover the power of leverage by comparing a hand-thrown spear to the atlatl. But remember, your ancestors hunted mammoths with this tool, so be careful!



## SAFE BAMBOO SWORDS

ALL AGES

Why wage neighborhood warfare with a flimsy, store-bought sword? Build your own long sword or a pair of close-combat daggers from lightweight bamboo and parent-friendly foam. Remember, true honor is earned, not bought.











## SCHOOL'S OUT: **OUTDOORS**



Nina's house is surrounded by lots of giant pine and redwood trees. The branches are too high for climbing, but with a little help from her dad, she and her pals use the trees to do something more exciting: they run a 45-foot zip line. To no one's surprise, it becomes the new hit attraction of the neighborhood, and they decide not to charge people admission — for now, anyway. They might reconsider if Josh keeps cutting in line! ➡



# BACKYARD ZIP LINE

BE THE HIT OF THE NEIGHBORHOOD WITH THIS HIGH-FLYING TREE-TO-TREE TRANSPORTER.

BY DAVE MABE



You could buy a dinky, ready-made kit with a short zip line for kids, but why not make your own industrial-strength zip line that will support even the heaviest grown-ups?

It's a fun project that you can tackle in a weekend. You can order all the parts on the web for less than \$400.

First, you'll need to find a suitable location for your zip line. Depending on the lay of the land, you'll be choosing between 2 basic types of zip line. If you'd like to put your on a steep hill, you'll need to use a *braked zip line* which has a brake block attached to bungee cords that slow you down as you approach the end of the line. If your site has a more gradual incline, you can use a *gravity stop zip line* that simply uses gravity to slow you down. I knew small children would be riding mine, so I chose a gravity stop because it's tamer, and our property layout made this option ideal.

## FIRST STEPS

I surveyed my property and identified 2 large oak trees that were far enough apart and only had a few tiny trees in between them. I measured the distance between the trees and

ordered the zip line parts online. For a permanent zip line, you'll need long eyebolts, drilled through the entire tree trunk, to attach the cable to. I knew I might move the zip line in the future, so I chose a more temporary technique to attach the cable.

Depending on the run you've selected, you'll need to determine how much cable to buy. It comes on a spool in multiples of 250 feet. Get more than you need because you'll need a bit of play on both ends.

While I waited for the supplies to ship, I started preparing the site. I cleared some small trees and underbrush to create a path between the 2 oak trees. I also started visualizing how far up each tree to attach the cable and how steep the slope should be. I knew there would probably be some trial and error, but taking time to plan ahead definitely minimized this once the supplies arrived.

You'll need a buffer between the cable and the tree it's attached to — otherwise, the tree will actually grow

around the cable and, over time, completely engulf it.

For this purpose, I bought three 1×6 boards of pressure-treated deck flooring and cut them into several 1-foot lengths. I drove the nails partway into the boards ahead of time, so I wouldn't have to do so on top of the ladder. I then nailed the boards into the tree vertically so that they encircled the trunk with small gaps in between them. This allows the cable to attach securely to the tree without actually touching it.

On a couple of boards, I drove a nail halfway in so the cable would be supported and wouldn't slide down.

## LAYING CABLE

When the cable arrived, I unwound some from the spool, climbed the ladder and circled the tree one full time, and then secured it with 2 cable clamps. Depending on the diameter of the tree, you may need a second person and ladder to help as the cable tends to be unwieldy, especially on top of a ladder.

I unwound the rest of the cable toward the other tree and nailed the boards to the second tree. Because the cable on the second tree is so



## MATERIALS

7x19 GALVANIZED AIRCRAFT-QUALITY  
CABLE, 250 FEET, <\$100

TWO-WHEEL ZIP PULLEY, \$160

DROP-FORGED CABLE CLAMPS (8)  
\$1.75 each

COME-ALONG (CHAIN PULLER) \$40

NYLON RUNNERS (2-3) <\$5

STEEL CARABINERS (2-3)  
around \$10 each

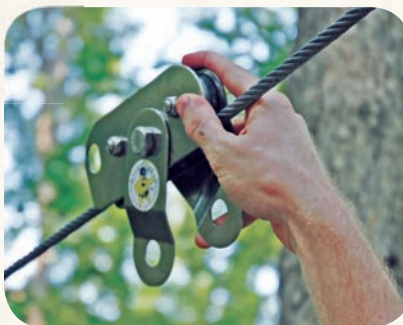
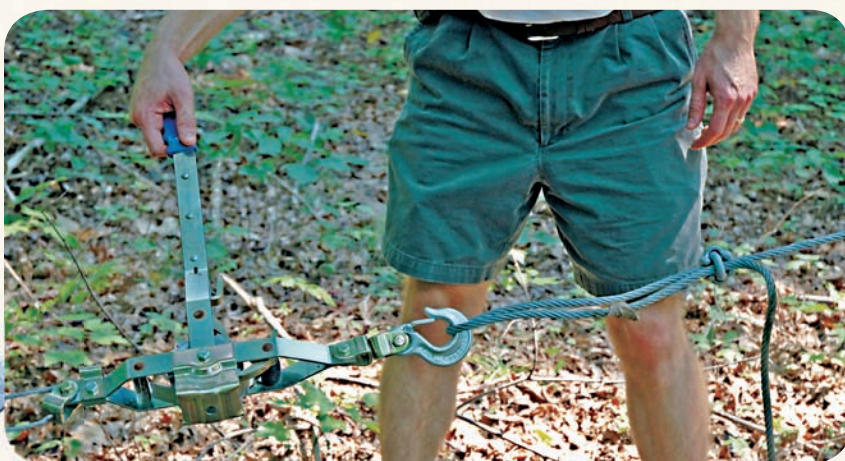
1x6 DECKING BOARDS <\$10 each  
3" NAILS

EXTENSION LADDER Try to borrow one!



high, I knew it would be difficult and dangerous to tighten the cable and clamp it at that height. Instead of risking life and limb, I took the cable halfway around the tree and then chose the base of another tree to secure and tighten the cable to. This allowed me to use the come-along (aka hand winch) to tighten the cable standing on the ground rather than at the top of an extension ladder.

To tighten the cable, I took it around the tree and put 2 clamps on the cable without tightening them. I then clamped a loop on the end of the cable so I could attach the come-along to it. Because there was so much tightening that needed to occur to raise the cable to the proper height, I captured the gain by tightening the cable clamps and then repositioned the come-along and the loop at the end of the cable. This took several repetitions before the



cable was tightened (and therefore raised) to a useful riding height.

## TEST RUNS AND SAFETY CONSIDERATIONS

For the first couple of rides, I started well shy of the top to make sure I wouldn't get a mouthful of bark if I hit the tree at the bottom of the run. I used a wooden handle from an old ax as a hanging bar and drilled an eyebolt through it. I used one of the carabiners to attach the pulley to the hanging bar. I then made more test runs by starting closer and closer to the top tree, carefully observing

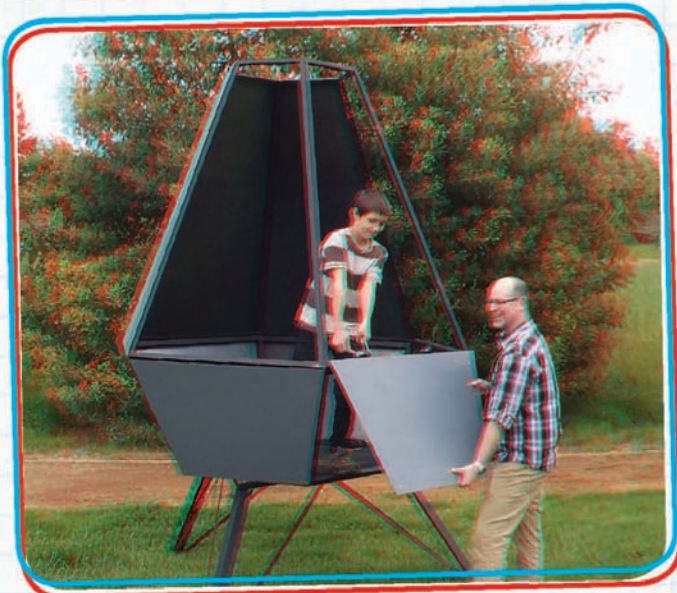
ground clearance and whether height adjustments needed to be made on the bottom tree to create more or less "gravity" at the end of the line.

Depending on the age, strength, and confidence of the rider, there are a variety of options for attaching the rider to the zip line. A climbing harness is the safest for younger riders, but it's time-consuming to transfer the harness between different riders.

Older and stronger riders can use a couple of nylon runners as a seat by simply attaching them to a carabiner and sitting in the loop. The strongest and most confident riders can simply hang from the wooden bar, although because of the height from the ground at the end of the line, this is discouraged due to safety concerns.

Dave Mabe is the author of *BlackBerry Hacks* from O'Reilly Media and lives in Chapel Hill, N.C.





# ROCKETSHIP TREE- HOUSE

ALL AGES ADULT SUPERVISION, FUN FOR GROUPS

»» The ultimate clubhouse, this **15' backyard rocketship** has 14 custom-programmed LED control panels inside and compressed air and water thrusters underneath, all controlled by a pilot joystick. When the authorized crew is all present, pull up the ladder to deny further entry. Upcoming in **MAKE Volume 31**, on sale July 2012.



## WOODEN MINI YACHT

ALL AGES ADULT SUPERVISION

Build a model boat that really sails across pools and ponds. You'll cut and drill the parts from wood and brass, then rig the mast, booms, and sails just like a real yacht, so you can adjust the angle (trim) of the sails to go in the direction you want.



## BASIC STILTS

ALL AGES ADULT SUPERVISION,  
FUN FOR GROUPS

Rise above the crowd with your own custom pair of stilts. Cut and drill the main pieces out of wood, sized to fit you just right. Then bolt on shin guards made from plastic pipe, sew on straps, and attach an old pair of sneakers with wood screws.





## BALSA GLIDER



12 & UP

Build a majestic, 5-foot-wingspan model airplane from balsa wood that flies better than toy-store plastic. This is a complete, from-scratch build, like in the old days, but updated with iron-on plastic covering instead of tissue paper. Fly it with R/C gear, or fly it free if you've got wide open spaces.

## BIKE REPAIR STAND

12 & UP

Every bike needs fixing now and then, but who wants to flip it over onto the seat and handlebars and work upside down? Build a stand out of ordinary plumbing pipe and wood that will make your bike workshop the best on the block.



**TIE UP  
A TOWER!**

## THE LOST ART OF LASHING

ALL AGES FUN FOR GROUPS

Imagine making forts, ladders, bridges, and rafts — just by lashing sticks together with twine. Learn how to wrap the twine to make strong joints and decking. Then make a tripod lookout tower and watch for pirates!

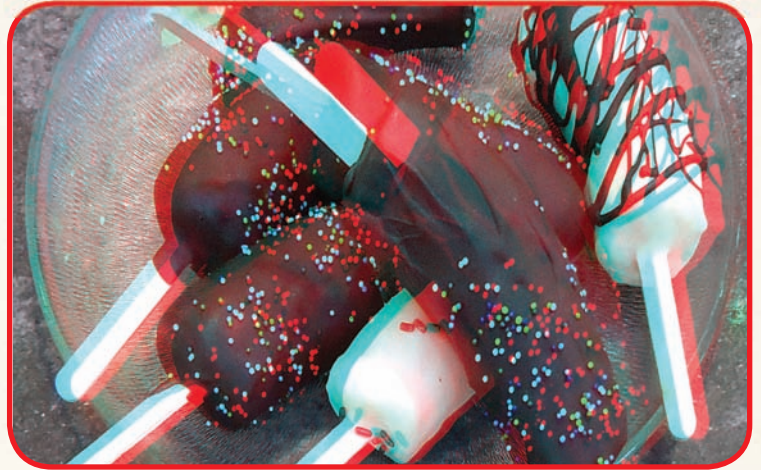








## SCHOOL'S OUT: **RAINY DAY**



A rainstorm puts a damper on the outdoor action, so the gang heads inside, where Ella shows everyone how to make frozen chocolate banana pops. They taste delicious, look impressive with sprinkles, and as the kids all learn, they're totally easy to make. The trickiest part: deciding who gets to lick the spoon (and the bowl) while you're waiting for the bananas to freeze! ➡



# CHOCOLATE BANANA POPS

EASY, FUN, AND DELICIOUS  
FROZEN TREATS. BY KATIE GOODMAN



## MATERIALS

FOR 6 CHOCOLATE BANANA POPS:

BANANAS, NOT OVERLY RIPE (3)

POPSICLE STICKS (6)

SEMISWEET CHOCOLATE, 5OZ

WHITE CHOCOLATE, 5OZ

SHORTENING, 3 TSP

RAINBOW SPRINKLES

CHOCOLATE SPRINKLES

## TOOLS

SMALL BOWLS (2)

SPOONS (2)

MICROWAVE OVEN

CUTTING BOARD

KNIFE

PARCHMENT PAPER

MEASURING SPOONS





Summer's here and the streets are filled with the sounds of kids playing outside — and the catchy jingle of the ice cream man. But you don't always have to shell out for those overpriced, mass-produced artificial treats. Instead, try these tasty, gourmet chocolate banana pops, and have fun decorating them in creative ways.

**1.** Peel the bananas and cut each in half, crosswise. Push a popsicle stick partway through the cut end of each half-banana so it looks like a popsicle.

Set the banana-sicles on a cutting board or plastic plate, and put them in the freezer while you prepare the remaining ingredients. Chilling the bananas will help the chocolate harden faster.

**2.** Put the semisweet chocolate and 1½ tsp of shortening in a bowl. Microwave the chocolate at 100% power for 30 seconds. Stir and repeat. Repeat a third time, if necessary, until the chocolate is completely melted.

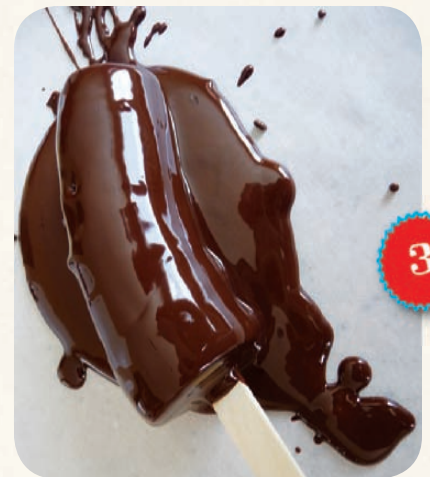
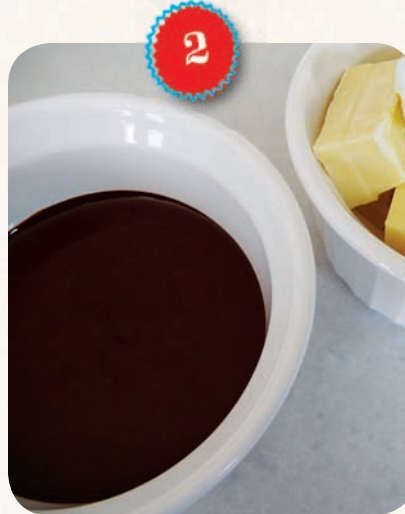
Repeat the process with the white chocolate.

**3.** Lay a sheet of parchment paper on the counter. Set out the sprinkles. Take 1 banana out of the freezer at a time. Place it on the parchment paper, and pour your chocolate of choice over the top. Turn the banana to coat all sides.

**4.** Decorate the banana with the desired sprinkles. Hold it for about a minute so the chocolate can set, then put it back in the freezer.

**5.** Scrape extra chocolate off the parchment paper and add it back to the respective bowl. If the chocolate becomes too thick to pour, remelt it in the microwave for 30 seconds.

Repeat this coating and decorating process with the remaining bananas.



**6.** After all the bananas have been covered in chocolate and decorated, chill them again in the freezer for 45–60 minutes. Enjoy!

Katie Goodman's lifelong interest in food has shown her that part of the goodness in life is enjoying delicious food with friends and family. She's the cook, recipe developer, and self-taught photographer behind GoodLife Eats ([goodlife-eats.com](http://goodlife-eats.com)), where she shares what she finds good in the kitchen and in life: great recipes, family memories, and yummy photography.





GET THE KIT AT  
MAKERSHED.COM/  
BRUSHBOT

# BRUSH-BOTS

ALL AGES GOOD FOR GROUPS

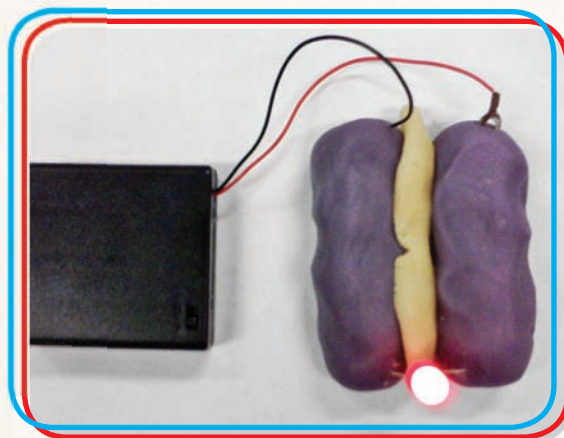
»» What can you do with an old toothbrush? Chop off the head and make it move! Using a tiny vibrating motor and a battery, **bring your toothbrush head to life**. Build a racetrack and see whose BrushBot crosses the finish line first!



## GIANT SPIN ART

12 & UP

Employ the spinning motion of a drill to make wild and beautiful paintings. Just build the wooden base, attach a canvas, start it spinning, and see what amazing patterns appear when you drop paint to canvas.



## SCULPTING CIRCUITS

ALL AGES

Take your play-dough creations to the next level by giving them light-up LEDs and moving parts. You'll learn to make a basic electronic circuit with this fun and simple tutorial. Play dough is actually already conductive, so you'll make two kinds: one conductive and one insulating. With a little help from batteries and a motor, you'll make a creature with glowing LED eyes and moving limbs!

Marc de Vinck (BrushBots); Patrick Harrell (spin art); Samuel Johnson (play-dough circuits)





## MINI TOY CAR LAUNCHER

12 & UP GOOD FOR GROUPS

Harness the power of the mighty rubber band! Build a mini toy car launcher using scrap wood, plastic, screws, and, of course, a rubber band. You'll flex your woodworking skills in this fun and simple project. Make two launchers and then race cars with a friend!

## RECYCLED KALEIDOSCOPE

ALL AGES ADULT SUPERVISION

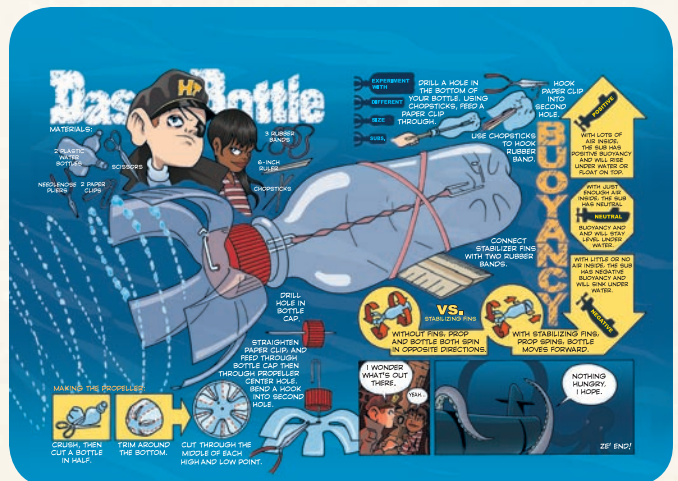
Using simple household supplies, build a mesmerizing kaleidoscope featuring your favorite bright and glittery bits and bobs. The magic component of a kaleidoscope is the triangle-shaped prism, which refracts and reflects light, making everyday objects look like part of a beautiful, ever-changing mosaic.



## BOTTLE SUBMARINE

ALL AGES

Make your very own rubber-band-propelled submarine out of an old soda bottle. Adjust buoyancy air levels inside the bottle to make your sub rise and dive. You'll learn why stabilizing fins are necessary: without them, the propeller and bottle spin in opposite directions, resulting in no forward momentum.



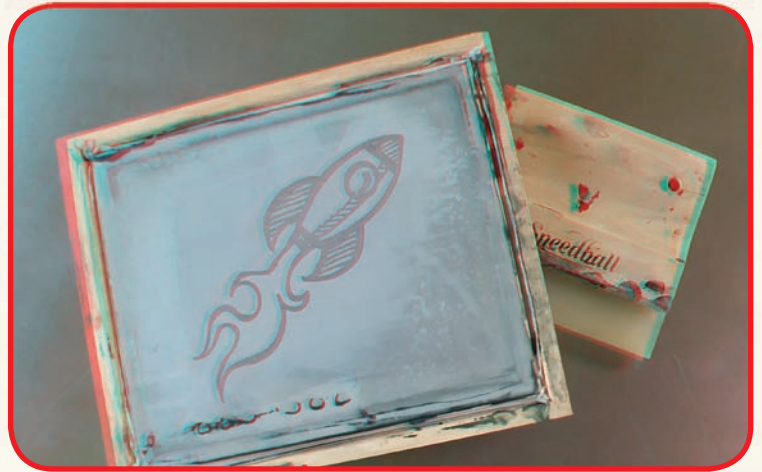








## SCHOOL'S OUT: **CRAFT**



Summer is T-shirt weather, and everyone wants a cool T-shirt. The kids decide to get crafty and wear their own designs, but puffy paint is way too babyish. So they build their own silk-screen setup. Screen-printing with a squeegee and globs of ink is so addictive they print their designs on everything in sight: hats, bags, wrapping paper. Actually, they go a bit overboard — hopefully Nina's mom won't mind about the pillows. ➡

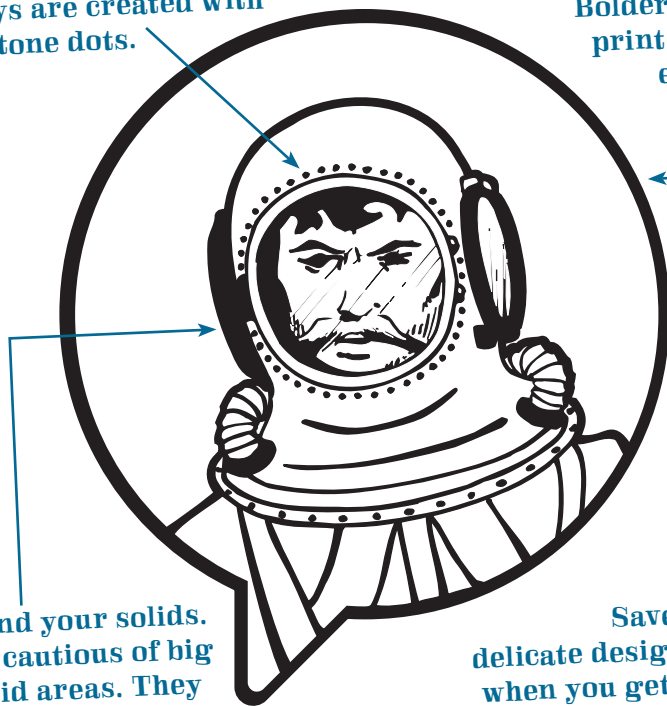


# SILK-SCREENING

PRINT YOUR DESIGNS ON ANYTHING YOU CAN HANG, WEAR, OR TOTE. BY KIRK VON ROHR

Design must be high-contrast. There is either on or off, positive or negative. Grays are created with halftone dots.

Take a bold approach. Bolder lines print more easily.



Mind your solids. Be cautious of big solid areas. They require lots of ink, and even coverage is tricky. On fabrics, they will crack after lots of washing.

Save your delicate designs for when you get a feel for the process.

Have fun with it!

## MATERIALS

DIAZO PHOTO EMULSION,  
made by Speedball

8"x10" SILK SCREEN tighter weave /  
higher mesh count allows for finer detail

8"x10" PIECE OF GLASS

SQUEEGEE

TASK LIGHTS WITH 150-WATT BULBS (2)

TRANSPARENCY PAPER for black and  
white copier/laser printer

FLAT BOARD that fits in or under what  
you're printing on

**SILK-SCREEN INKS** These are fast-drying acrylics. Createx and Speedball work well. The only opaque colors are opaque white, black, and a few metallics. Other colors will combine with the color of the print surface. To help colors stand out on dark material, mix in some opaque white.

## OPTIONAL:

FAN I use a small Vornado.

DIAZO PHOTO EMULSION REMOVER  
if you want to clean your screen and  
start over

VERSATEX FIXER Mix a few drops into  
your ink to make it permanent and washable,  
without ironing.

ALL AGES  
ADULT SUPERVISION



A silk screen lets you duplicate sharp, vivid designs on any flat fabric. All you need is a sink and an open workspace.

The key ingredient is photo-hardening emulsion, which you spread over a porous screen and then expose to light under a mask with your design. Wash the unexposed emulsion away, and you've got a durable stencil that will make up to 200 prints with any color ink.

Create your design on a computer and laser print it onto a transparency, or draw it straight onto transparency paper using India ink. Either way, you need a solid black positive image that looks like what you want to print, not a mirror image.

## 1. PREP THE SCREEN

Mix the photo emulsion as per the directions, then coat the screen with it, working fairly quickly over a sink or surface you can get messy.

It's OK to have indoor lights on during this process, but keep out of direct sunlight. The emulsion needs to be applied evenly, so keep flipping the screen over and squeegeeing until the emulsion is even on both sides. Any globs will cause uneven exposing and will mess up your end result. The thicker the emulsion is applied, the longer the screen will have to be exposed.

The screen needs to be completely dry in order to expose it, and should be dried in a pitch-black room. I dry my screen by resting the wood frame on a couple of shoe boxes in the closet, so that the screen is parallel to and above the floor. This allows the air to flow above and below the screen to help it dry faster. Make sure that only the frame touches the boxes, so as not to mess up the nicely applied emulsion. You can place a fan (I use Vornado because they are compact) next to the screen. Drying it this way takes 30 minutes to an hour, depending on humidity.



## 2. EXPOSE THE SCREEN

Now that it's dry, place the screen on your workspace with the bottom facing down. Put your transparency on the screen in the center and as squarely as you can, face up, just as you want it to print. Then place a piece of glass on top. This holds your transparency down so it makes direct and even contact with the screen. If it doesn't make direct contact, then your design will appear fuzzy around the edges.

The light source needs to be placed about 12 inches from the screen to get good results, and it

needs to shine evenly across your design. I use two \$10 task lights. These are great because they allow me to easily adjust my light source, and by having 2, one on either side of the screen, I can make sure the entire design gets an even, direct supply of light. Follow the directions that came with the emulsion for exposing your screen. It varies with the bulb and screen size. I'll burn my screen for about 30 minutes. You can tell when the screen is done by looking: the exposed areas turn dark green when they are baked solid by the light.



**TIP:** For a super-dense positive, make two transparencies with your design on them. Line them up and attach them together with double-sided tape.

### 3. WASH AND DRY SCREEN

Now that the screen is exposed, wash it off in the sink with hot water. It takes some force to wash the screen effectively. I've attached a special nozzle to my faucet that creates higher pressure. (I got a nozzle at Bed Bath & Beyond for \$5. Just screw it on and it'll toggle between high and low. Works great for dishes too; I leave it on all the time.)

Along with spraying, you can gently rub the screen with your fingers. Don't use your fingernails. If you force the emulsion off, you run the risk of tearing off the hardened emulsion, putting you back to Step 1. You want only the unexposed area to wash off.

Under hot water, the emulsion will become slightly gummy. Drying the screen isn't such a big deal this time around, now that it isn't sensitive to light. Prop it up against the fan, or place it where it can get some air. Silk dries quickly.

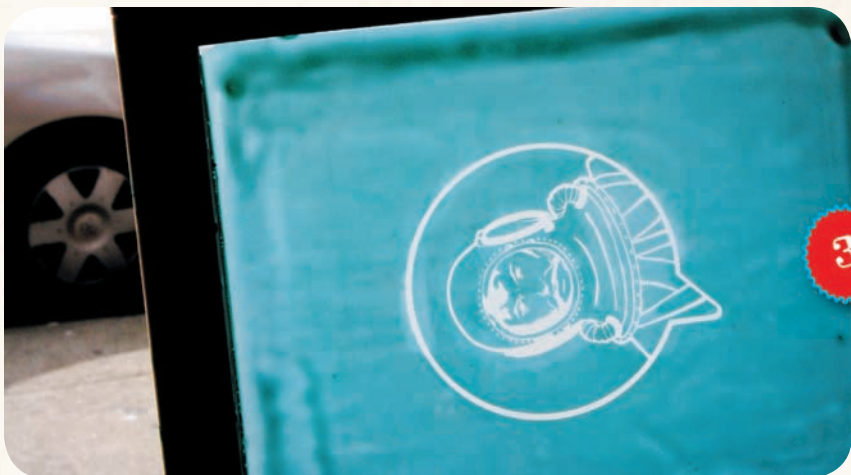
### 4. PRINT ON PAPER

Now that the screen is exposed, washed, and dried, print it and see how it works. Try it out on paper first.

Lay the screen down flat, making sure that your surface is even and flat. With a spoon, put a glob of paint on the screen and spread it the width of your design. Don't get any on the design itself, just the area above it.

Now the fun part. Hold the screen down firmly with one hand (or have a buddy help hold it). Use a squeegee to pull the ink down to the bottom of the screen. Apply a small amount of pressure to the squeegee as you pull the ink.

You'll be able to see the paint evenly distributed across the screen. Ideally you should only have to spread the paint downward once, and when you pull down, you should feel it sliding evenly over the screen. But if it's grabbing in areas, then



#### Q: ARE SILK-SCREENING INKS SPECIAL? HOW DO THEY DIFFER FROM OTHER PAINTS?

**A:** Silk-screening inks are acrylic. They dry quickly, and are water-soluble and transparent. Due to the transparent nature of the ink, it will interact with the color of the object you are printing on (example: blue ink on yellow shirt will turn slightly greener; blue ink on a black shirt will be barely legible).

White, black, and a few metallics are the only completely opaque ink colors. White also comes in extra opaque, which I recommend. If you want to print on a dark material, mixing some opaque white into the color will help it stand out.



there isn't enough ink in that spot. This is one of the telltale signs that your print needs another pull of ink. With practice, you'll get a feel for it.

Lift the screen and look at your beautiful print! Be very careful when you lift off the screen. Try to peel it slowly and directly up, so you don't smudge the fresh ink. It may want to stick to the paper.

It's as easy as that! Lay the screen down on another piece of paper and do a few more prints for fun.

## 5. PRINT ON FABRIC

Now that you have some practice and a feel for things, let's print a lap-top bag. Start with a clean screen.

Since the bag is soft, I need to put something stiff inside the bag to make the printing surface a little harder. In this instance, I used my old cutting mat.

Put some masking tape down on the bag as a guide to help line up your screen. The emulsion is just slightly transparent, and you can see the tape through it. Once it's into position, hold it down, glop some paint, and make a nice swish of the squeegee. Lift off the screen and take a look. Beautiful!

**TIP:** Do a few test runs so you can practice getting good ink coverage and squeegee pressure. It's good practice to test your screen on some scraps of material that are similar to what you want to put your design on.

## 6. CLEAN UP

Place your finished product somewhere to dry (it will take 15 to 30 minutes). Immediately wash your screen — the ink dries fast and can ruin your screen.

You can make about 100–200 prints with your screen. When doing a long run, you may have to periodically wash out your screen between prints to keep the paint from clogging your design.

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Kirk von Rohr was the founding Art Director of MAKE. You can still find him in his bay area studio making messes and taking things apart. Sometimes he dreams in Robot: Beep beep boop.

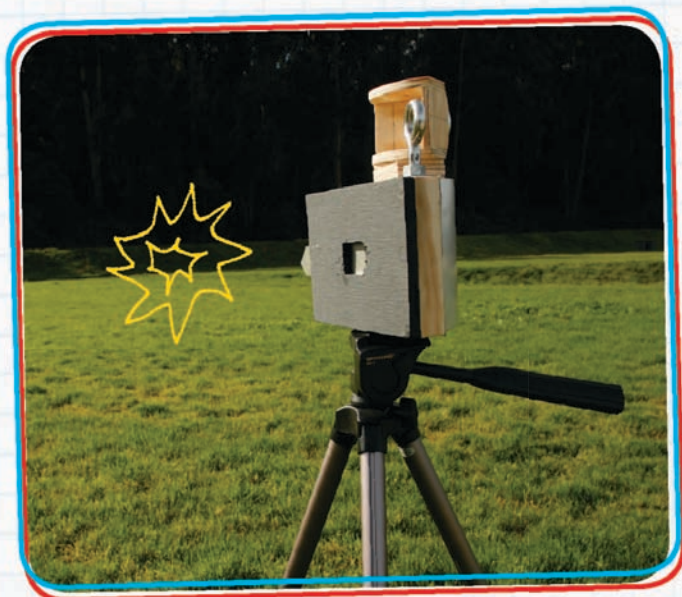


## MAKE IT WASHABLE

If you are printing on a shirt, you need to do another step to make it permanent. Here are 2 options:

- » Iron the shirt on a high, dry setting, placing wax paper between the shirt and the iron.
- » Add a few drops of an additive like Versatex Fixer to the paint before you apply it to the shirt. You can mix it right into the ink container.





# PINHOLE PANORAMIC CAMERA

12 & UP

»»» There is a cult following of pinhole cameras and photography. Initiate yourself by building your very own **pinhole camera** out of wood. You'll learn the basics of how a camera works, and the feeling of building a machine that can capture images is utterly amazing.



## WOVEN MAP BASKET

ALL AGES

Transform old map from your road trip into a woven basket that holds your trip souvenirs. Or experiment with other printed materials: the Sunday comics, wrapping paper, or even your own design drawn on a paper bag!



## HOME PERFUMERY

12 & UP

How do you capture a natural fragrance? Through a process known as steam distillation. Build a still to extract the scent from rosemary, lavender, mint, eucalyptus, and other scented flora. Then use the essential oil you collect to add scent to things like soap, lotion, or even your bathwater!

Sam Murphy



## PRECIOUS METAL CLAY

ALL AGES ADULT SUPERVISION

Ever wished you could sculpt metal like clay? You can, with precious metal clay (PMC)! PMC is actually powdered metal suspended in a clay-like binding medium. Create something, fire it with a torch, and you're left with a shiny sculpture of silver or gold!



EASY AS CLAY, BUT SHINY AS METAL!



## PAPERMAKING

ALL AGES ADULT SUPERVISION

Want to recycle old homework and junk mail into something beautiful? Give them new life by transforming them into homemade paper! This project will call on your woodworking skills as well as your artistic eye. Try mixing different colors and paper styles.



## LINOCUTS

12 & UP

Turn your drawing into a linocut that can be printed over and over again. You'll hack up a block of linoleum with your design, roll ink over it, and then make prints! Each one will be unique, depending on your technique!



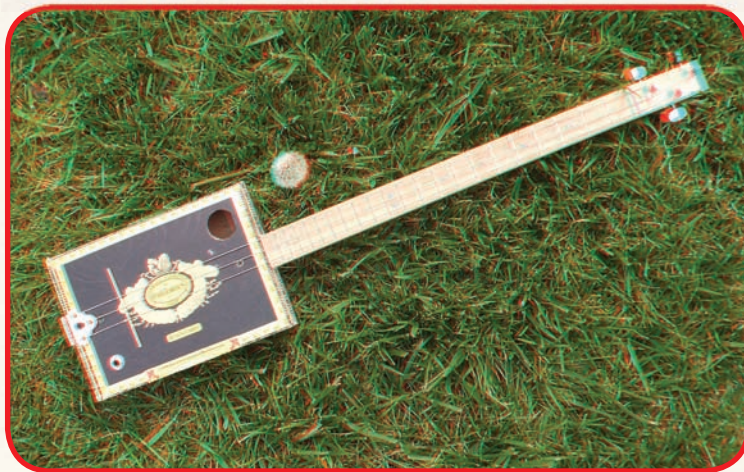








## SCHOOL'S OUT: **MUSIC**



After all that quiet, patient crafting, the crew decides to make some noise! Leo builds a sweet-sounding cigar box guitar, and then hooks it up to his portable cracker box amp, which only cost him about 30 bucks in components. His parents are so impressed that they insist he and the girls jam at their neighborhood barbecue, with Ella on washtub bass and Nina on the washboard. Once the party gets going, Leo doesn't mind too much. ➡



# TRADITIONAL CIGAR BOX GUITAR

HAND-ROLLED MUSIC. BY MARK FRAUENFELDER

Because every cigar box guitar (CBG) is built by hand, using different found and scrounged materials, no two sound alike.

I love the suspense of not knowing what kind of “personality” a CBG is going to have until it’s completed. Here’s how to make a plain-vanilla, 3-string CBG that requires a minimum of tools and parts and yet sounds great.

## 1. MAKE THE NECK

Making the neck and installing the frets are the most time-consuming parts of the build. Once you’ve prepared the neck, you’ll be surprised by how fast the rest of the build goes!

**1a.** Using a wood saw, cut the oak or maple lumber to 36". Measure and trace the length and thickness of the cigar box lid against one end of the lumber stick. Saw away this part, shaded red in the illustration. This is the end that will go inside the cigar box, and the cutaway lets the fret-board sit flush with the front.

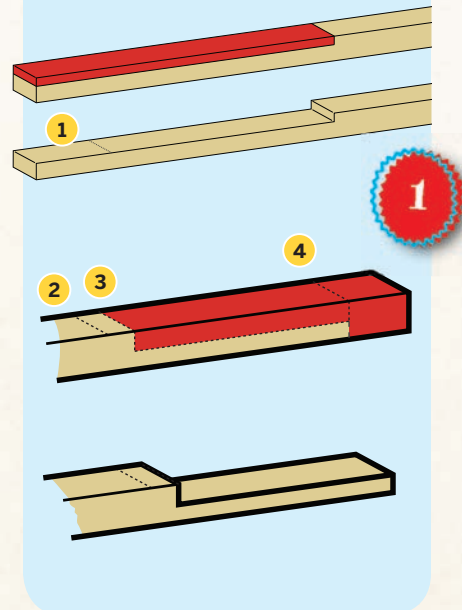
**1b.** Decide on a scale length for your guitar, the distance from the bridge to the nut. Most guitars have a scale length between 24" and 25½". For a cigar box bass, try 30"–34".

**1c.** Make a pencil mark 2¼" from the bottom end of the stick, for the bridge. From this mark, measure up your scale length (I decided on 24 ½") and make another mark for the nut. Make a third mark ½" farther past the nut and then a fourth and final pencil mark 3½" beyond the third mark, near the other end of the stick.

**1d.** Cut the stick off at the fourth pencil mark, then cut away the headstock (the part where the tuning pegs go) between the third and fourth marks, removing the material shaded in red at right. The headstock should be half as thick as the neck, or ¾".

**1e.** Sand the top surface of the neck so it’s dead flat. Use a sanding block, starting with rough sandpaper and finishing with fine-grit sandpaper.

12 & UP



Mark Frauenfelder



## MATERIALS

For Materials notes and sources, and a Tools list, see [makeprojects.com/project/a/87](http://makeprojects.com/project/a/87)

### CIGAR BOX

OAK OR MAPLE LUMBER,  
1x2, 3' LENGTH

GUITAR STRINGS, MEDIUM-GAUGE:  
#5, #4, AND #3 (A, D, AND G)

### TUNING PEGS

FRET WIRE, MEDIUM GAUGE

Flat toothpicks or small clipped nails will also work, or you can also go fretless, which is great for slide guitar.

CABINET HINGE with 3 mounting holes on each side

1" WOOD SCREWS (6)

BAMBOO BARBECUE SKEWER or other hard, thin, solid object

SUPER GLUE (OPTIONAL)

OPTIONAL MATERIALS, FOR GOING ELECTRIC:

PIEZOELECTRIC BUZZER

AUDIO JACK, ¼" MONO

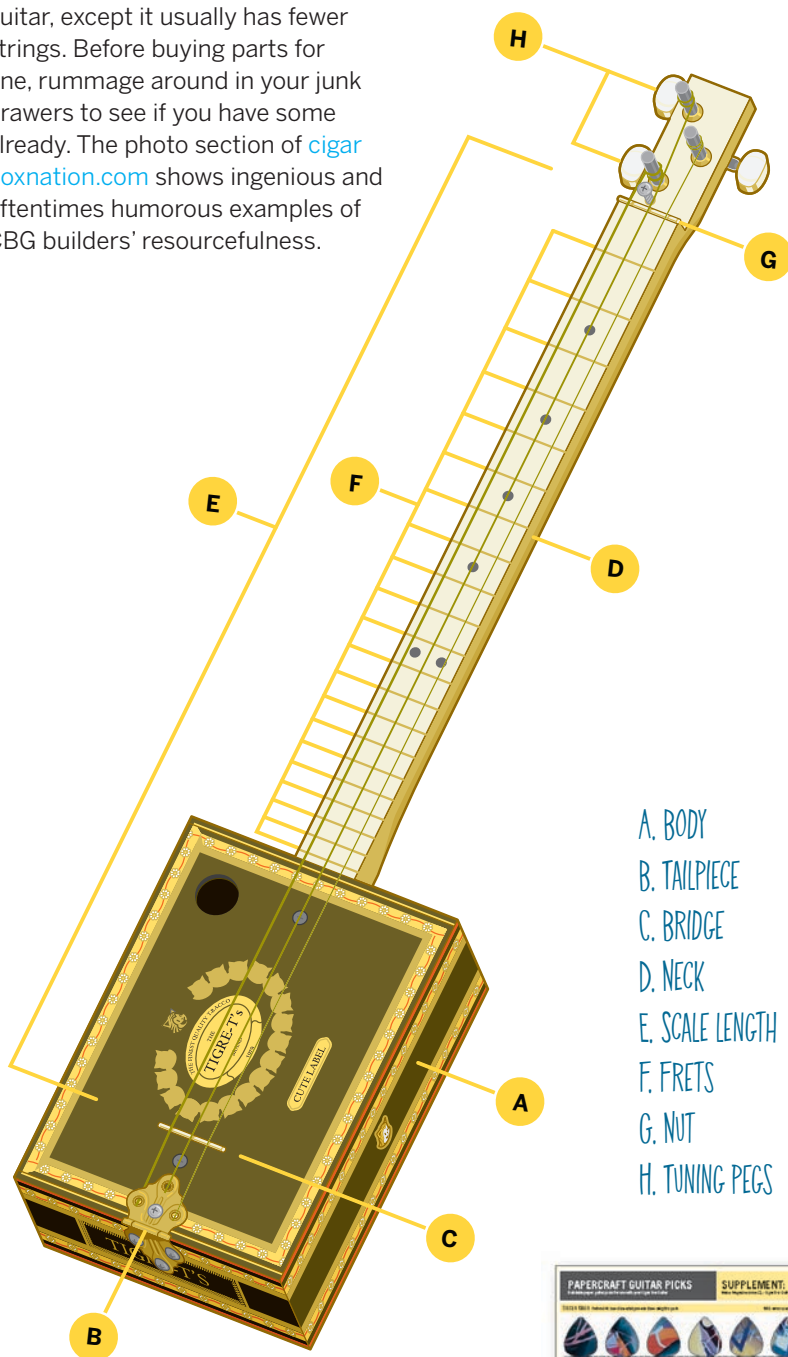
WIRE, 22 GAUGE, INSULATED, STRANDED

## FREE LESSONS

Cigar Box Nation ([cigarboxnation.com](http://cigarboxnation.com)) is a fantastic online hangout for homemade stringed instrument enthusiasts, and includes a terrific series of video lessons by Keni Lee Burgess and Shane Speal on how to use a bottleneck slide.

## A STRING, A STICK, AND A BOX

A cigar box guitar is like a regular guitar, except it usually has fewer strings. Before buying parts for one, rummage around in your junk drawers to see if you have some already. The photo section of [cigarboxnation.com](http://cigarboxnation.com) shows ingenious and oftentimes humorous examples of CBG builders' resourcefulness.



- A. BODY
- B. TAILPIECE
- C. BRIDGE
- D. NECK
- E. SCALE LENGTH
- F. FRETS
- G. NUT
- H. TUNING PEGS

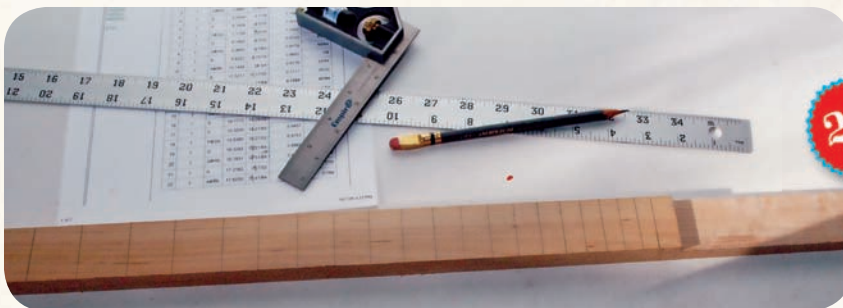
**Bonus!** Illustrator Rob Nance created a sheet of Papercraft Guitar Picks to help you rock out in style with your new cigar box guitar! Get it at [makezine.com/21/cbg](http://makezine.com/21/cbg).





## 2. INSTALL THE FRETS

**2a.** Enter your scale length and number of frets (I chose 21) into an online fret calculator (see [makezine.com/21/cbg](http://makezine.com/21/cbg)) and print out the table it generates. Using a decimal-inch yardstick and a square, make pencil marks along the length of the neck to indicate the location of the frets. Take your time and make careful measurements, and you'll have no problem.



2a

**2b.** Use a coping saw and miter box to cut the fret slots about 5" deep. The saw blade should be thin enough so the fret tangs bite into the slots you cut.



2b

**2c.** Along the back of the neck, use a Surform shaver to round out the sharp 90° edges into soft curves, so your fretting hand can easily slide up and down. Follow up with sandpaper until the wood is very smooth.

**NOTE:** Don't shave the headstock or the part that will fit into the cigar box — only work on the area under the frets and nut.



2c

**2d.** At each fret slot, take a piece of fret wire (it usually comes pre-cut) and press its barbed center rail into the slot, with each end overhanging the side of the neck. Place a thin block of wood on the fret and tap on the block with a hammer until the fret is all the way in.

**NOTE:** You can smear a tiny bead of super glue across the part of the fret that fits in the slot if you wish, but I usually skip it, because it's hard to keep the glue from getting onto the neck.



2d

**2e.** Clip the fret wire almost flush with the neck. Repeat Steps 2d and 2e until all frets are installed.



2e



**2f.** Use a file to smooth the sharp, cut ends of each fret into gentle curves. (You can inspect a store-bought guitar to see how frets should look.) Run your hand up and down the neck. If your skin snags, you need to keep filing! Use a magnifying glass and look for any small burrs that need to be filed off with a jeweler's file.

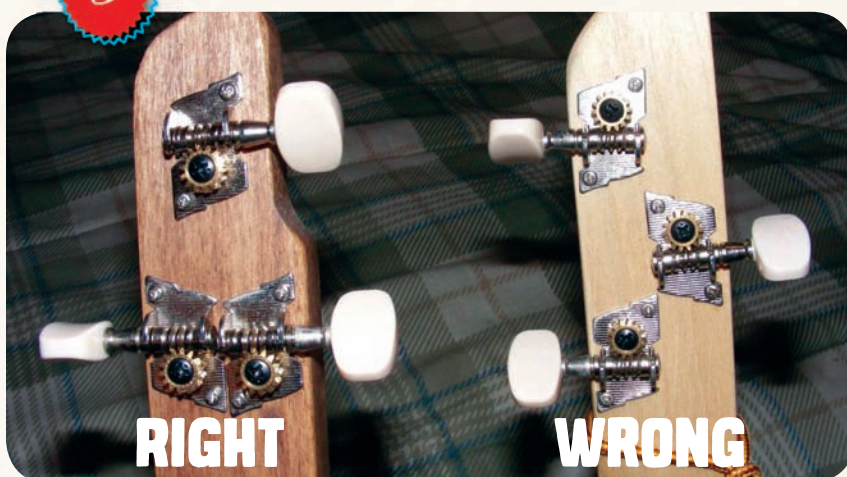


### 3. INSTALL THE TUNING PEGS

Study the geometry of your tuning pegs and determine where to position them on the headstock so that the strings and pegs won't interfere with each other. Mounting screws shouldn't be too close to the edge of the headstock, or they might split the wood.

For each peg, drill a large hole for the post and 2 pilot holes for the mounting screws. A drill press will make things easier, but if you use a handheld drill, try your best to drill straight down.

On the back of the headstock, make sure the tuning pegs' winding shafts are above their gears, not below. If you mount the pegs upside down, your strings will go out of tune more easily.



### 4. FINAL ASSEMBLY

**4a.** Measure the cross section of the part of the neck that fits inside the box, and draw a matching rectangle (for a 3-sided notch) on the inside of the box. Cut the 2 vertical lines with a coping saw, then use a utility knife to score the horizontal several times until you can snap off the rectangle.

Insert the neck, close the lid, and make sure the fretboard sits flush with (or a tiny bit higher than) the lid. If the fretboard is lower, sand down the cut-away part of the neck until the fretboard and lid are flush.





**4b.** Drill a pilot hole in the far end of the box and drive a screw through the box into the end of the neck. Close the lid and then pilot-drill and drive 2 more screws into the front of the neck, through the lid of the box near each end (to install a pickup later, you can remove these screws).



**4c.** Center and fold the hinge over the front lower edge of the box, then drill pilot holes and screw it to the box. The hinge will sit over the screw you inserted in Step 4b.



**4d.** Use paint or a Sharpie to make position marker dots above frets 3, 5, 7, 9, and 12.

To string the guitar, thread the barrel ends of the strings through the hinge's unused mounting holes. Wind the other ends onto the tuning pegs, but not too tight yet. Here's a good video that will teach you how to wind a guitar string: [makezine.com/go/guitarstring](http://makezine.com/go/guitarstring).

**4e.** Cut your bridge and nut pieces to size (I used a wooden barbecue skewer). Place one piece under the strings at the line you drew for the nut, then measure down your scale length and fit the bridge piece underneath at that location.

Drill an extra hole through the tailpiece hinge and drive a screw through it into the lid and the neck. This will increase tension on the strings and prevent rattling.



**NOTE:** I added a screw to center the middle string in the headstock. You might have to do this, too.

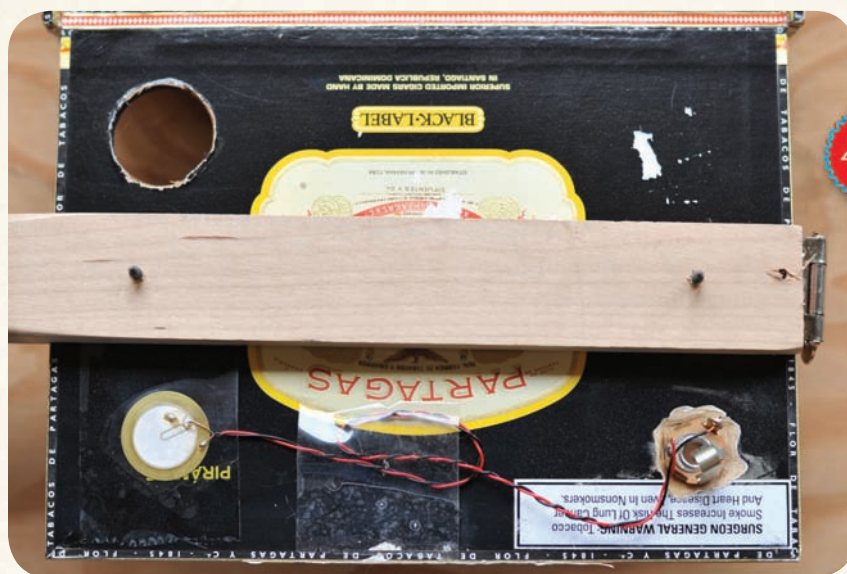




**4f.** Use a small hole saw ( $\frac{3}{4}$ " diameter or so) to cut a sound hole in the front of the box. Make sure to position the hole so it doesn't cut into the neck. You've built your guitar!



**4g.** (Optional) To go electric, screw or glue a piezoelectric buzzer against the inside the cigar box, and wire its 2 contacts to a  $\frac{1}{4}$ " mono audio jack mounted to the box where convenient. Plug in a patch cord, and you're ready to amplify.



## TUNING

The most popular tuning for 3-string cigar box guitars is "open G," in which the strings are tuned to G, D, and G — like strings 2–4 of a 6-string guitar with open tuning.

## MAKE A BOTTLENECK SLIDE

(Optional) Bottleneck slides sound great with open tuning. To make one, get your folks to score a ring around the neck of an empty wine bottle with a Dremel cutting disc (wear eye protection). Wearing oven mitts, tap the score line with a spoon and snap off the neck (do this over a trash can to capture the shards). Sand the rough edges, and you've got something far superior to a store-bought slide.



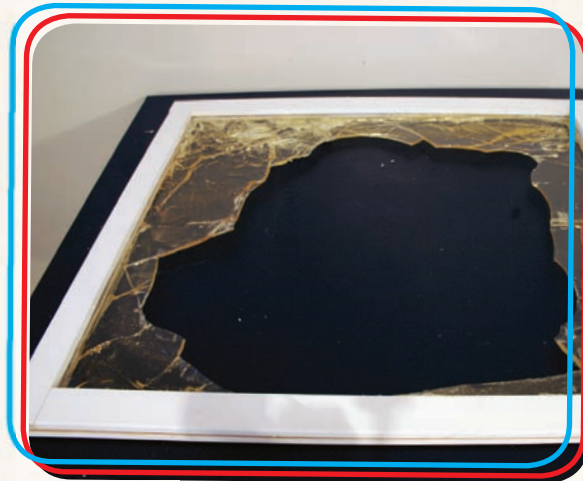
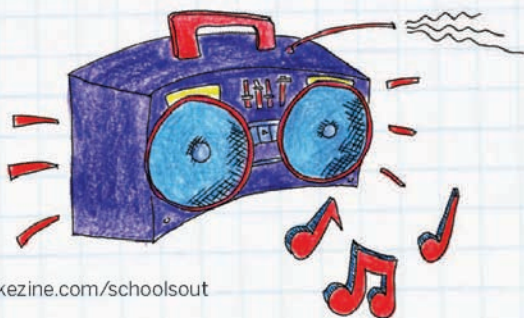




# CRACKER BOX AMPLIFIER

12 & UP

»»» Finish up those crackers and make **a tasty box that rocks** for about \$30 in parts. You can build this perfect match for your cigar box guitar using only a soldering iron and glue gun. It's loud, clear, and sure to get you noticed.



## ACTION MOVIE EFFECTS

ALL AGES ADULT SUPERVISION

Make a smashing appearance in your rock video by breaking through "glass" made out of sugar and corn syrup, the way the special effects pros do it. Cook up the mixture in your kitchen, pour it, and in just 2 hours, you're ready to roll!



## FIREBALL SHOOTER

12 & UP ADULT SUPERVISION

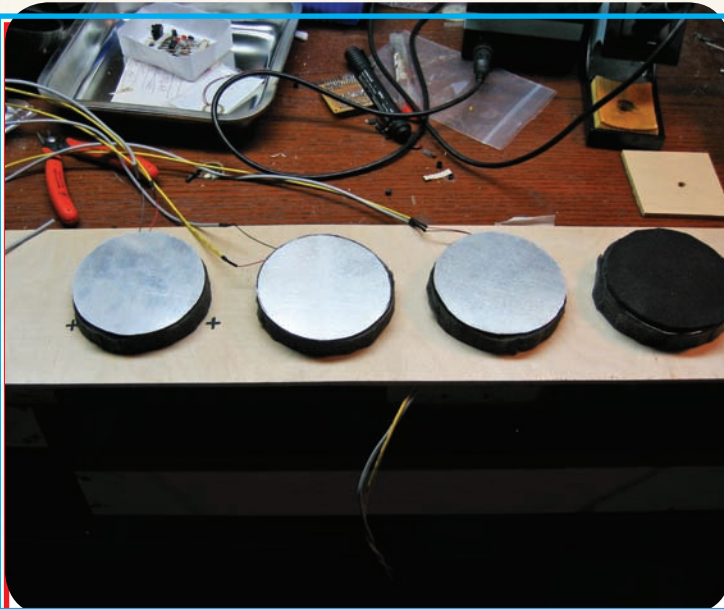
What rock star doesn't want to shoot flames? Whip up a mini, handheld fireball shooter using a \$4 glo-plug, batteries, and a binder clip, and turn up the heat in your live performance. Hot!



## THUMB PIANO

ALL AGES

You were born knowing how to play the thumb piano. This awesome little instrument can be made using anything from a salad bowl to a wooden box for the body, and anything that will vibrate when plucked for the tines (bike spokes, knitting needles, whatever you've got).



## DRUM KIT KIT

12 & UP

Real drum kits take up a lot of space, but you can turn anything into a drum set using an Arduino and this simple kit. Solder up the PCB, then get creative making your own custom drum pads from just about any material. Hook it all up to your computer, and drum the day away.

ONE-STRING WONDER

## DIDDLEY BOW

ALL AGES

Put a little twang in your tune with this one-string slide guitar. Using just a board, some wire, nails, and a glass jar, this instrument is so easy to build, you won't believe how cool it sounds.

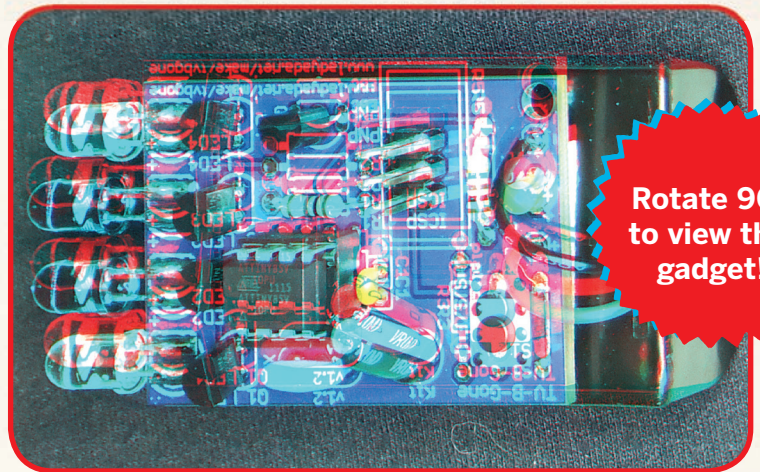








# SCHOOL'S OUT: PRANKS



Idle time is the devil's playground — which is why all good summer vacations inevitably turn to pranks. Leo teaches his brother and the girls how to solder, and then they put together a TV-B-Gone kit that can turn any TV off. After dinner, they catch the boys' dad watching a baseball game and do their best to stifle the giggling as he keeps trying to turn the blasted TV back on. Needless to say, they couldn't keep quiet for long. ➡



# SUPER TV-B-GONE

IT'S EASY TO ASSEMBLE THIS KIT, THEN ZAP TV SCREENS FROM HUNDREDS OF FEET AWAY.

BY NICK BRENN

12 & UP



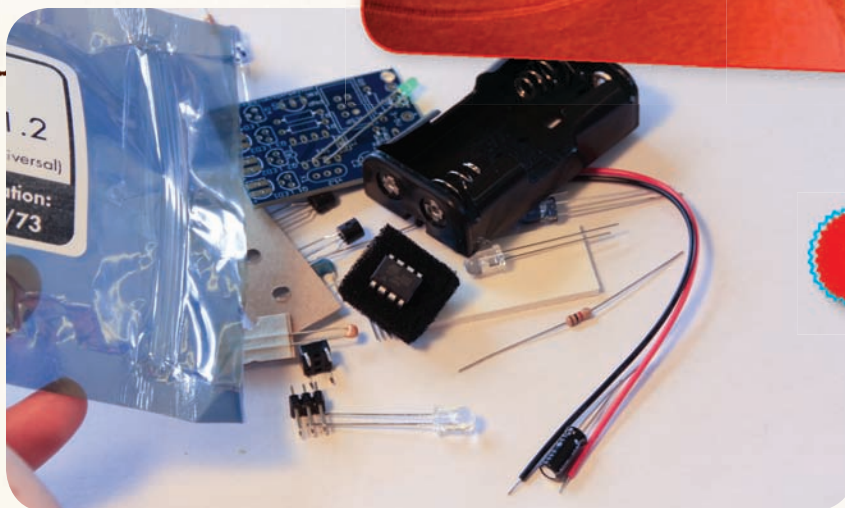
Tired of all those big-screen TVs everywhere?

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 just what you need. With just a simple click of the button you can turn off any TV from hundreds of feet away. Zap!

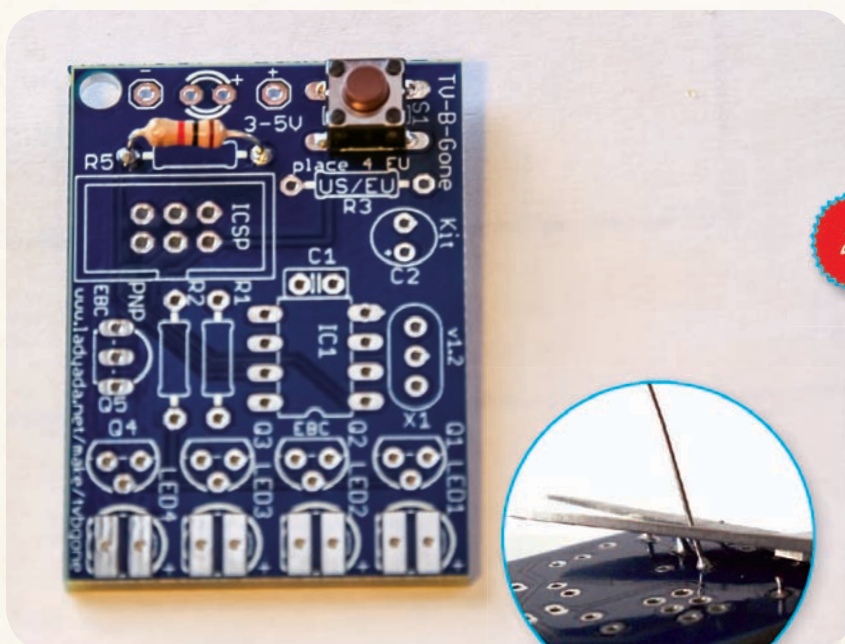
**1.** First, check that you have all the required parts; if not, check under your chair!

**2.** Plug the pushbutton switch into the S1 spot on the board, then turn the board over and solder the connections. It doesn't matter which way the switch is oriented. Similarly solder one of the 1K resistors (brown-black-red-gold) either way into the R5 position.

**TIPS:** To make sure the components stay in the board when you turn it over, bend the leads outwards a little after inserting them. Clip long leads short after soldering to prevent short circuits on the back of the board.



1





## MATERIALS & TOOLS

The following materials, except for the batteries, are available as the Super TV-B-Gone Kit from Maker Shed (item #MKAD4 at [makershed.com](http://makershed.com)):

**TV-B-GONE PRINTED CIRCUIT BOARD (PCB)** If you want to make your own, the Eagle design files are available at [ladyada.net/make/tvbgone/download.html](http://ladyada.net/make/tvbgone/download.html).

**MICROCONTROLLER IC CHIP, ATtiny85V-10P** If you don't buy the kit, you'll need to program this with the TV-B-Gone firmware.

**IC SOCKET, 8-PIN**

**CERAMIC OSCILLATOR (AKA RESONATOR), 8MHZ**

**LEDs:** 5MM WIDE-BEAM INFRARED, 940NM (2); 5MM NARROW-BEAM INFRARED, 940NM (2); 3MM GREEN, 565NM (1) These are Everlight #IR333C/H0/L10, Everlight #IR333-A, and Kingbright #WP7104GD.

**TRANSISTORS, NPN:** PN2222 (4), PN2907 (1)

**PUSHBUTTON SWITCH, SPST 0.05A**

**CAPACITORS:** 0.1 $\mu$ F CERAMIC (1), 220 $\mu$ F ELECTROLYTIC (1)

**RESISTORS:** 1K $\Omega$  (2), 10K $\Omega$  (1; FOR USE OUTSIDE OF USA/ASIA)

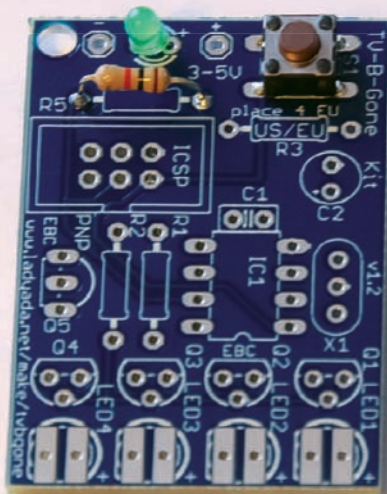
**BATTERY HOLDER, 2xAA**

**FOAM TAPE, DOUBLE-STICK aka sticky foam**

**BATTERIES, AA (2)**

**SOLDERING IRON AND SOLDER**

**WIRE CUTTERS AND STRIPPERS**

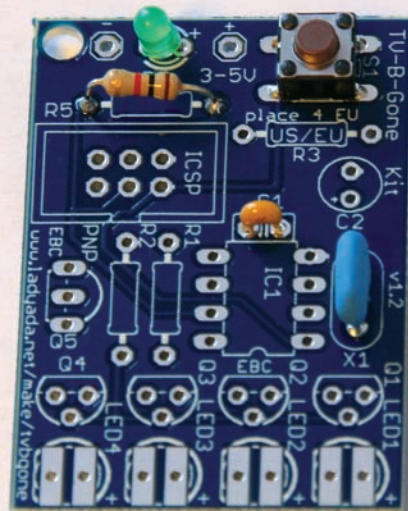


3

**NOTE:** On LEDs and polarized capacitors, the longer lead is the positive (+), aka anode, and the shorter lead is the negative (-), aka cathode.

**3.** Insert the small green LED into D5, with its longer lead in the pad marked (+) on the board and its shorter lead in the (-) hole.

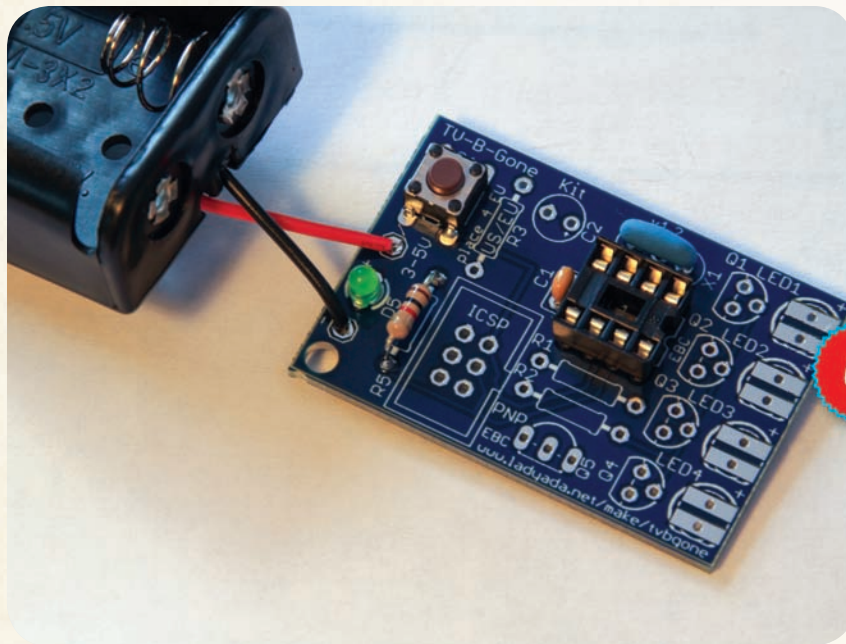
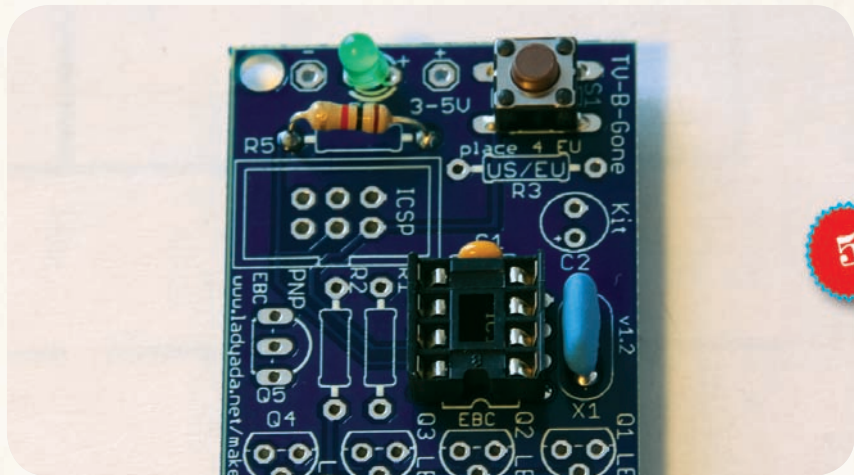
**4.** Plug and solder the 0.1 $\mu$ F ceramic capacitor (marked "104") in either direction into C1, and the 8MHz oscillator in either direction into X1.



4



**5.** Plug and solder the 8-pin socket into the position marked IC1, with the notch at one end oriented as indicated. Make sure the socket is flush with the board.

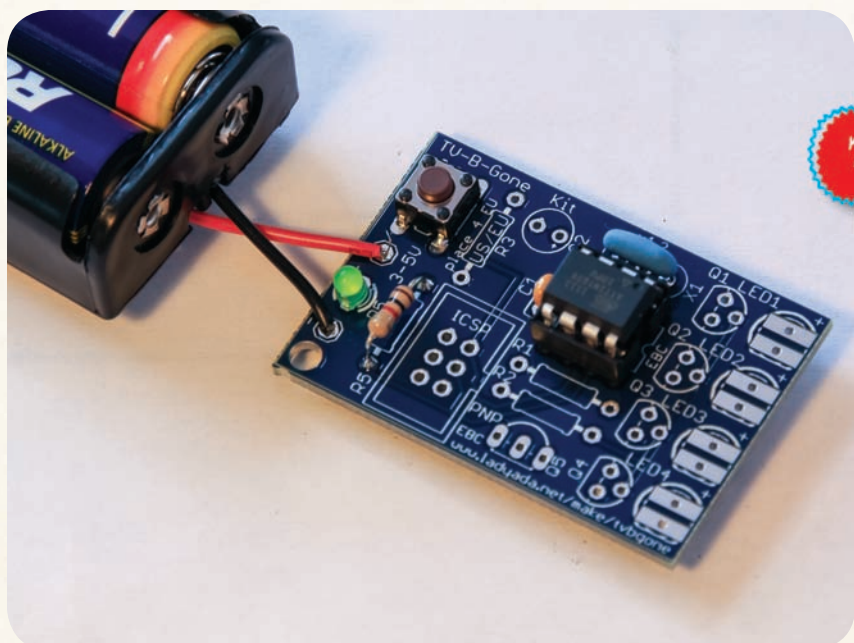


**6.** Trim the battery holder leads until only about one-quarter of the wire remains, then strip the ends to expose about 1/4" of bare wire. Solder the red lead into the (+) pad at the bottom edge of the board and the black lead to the negative (-) hole.



**7.** Do an intermediate test by plugging the programmed micro-controller chip into the 8-pin socket with the chip's small dot (pin 1) at the notch side, and load 2 AA batteries into the holder. The LED should blink. (If not, check your connections and make sure all components are oriented as instructed.)

Remove the batteries before continuing assembly.





**8.** Solder the other 1K resistor into position R1, running in either direction, and the 220 $\mu$ F capacitor into C2, with its longer lead on the (+) side.

**9.** Push the 2907 transistor into hole Q5 with its flat end facing outward on the PCB, matching the silkscreen, and solder the leads in.

Similarly solder the four 2N2222 transistors into Q1, Q2, Q3, and Q4.

**10.** Finally, install the 4 infrared LEDs. You'll want them to aim forward, so leave some bending room when you solder them into the PCB. Install the blue-tinted narrow-beam LEDs in the middle spots, LED2 and LED3. Put the clear, wide-beam LEDs on either side, in LED1 and LED4. Orient them all as indicated, with their longer legs on the side marked (+).

After you solder in the LEDs, bend them forward.

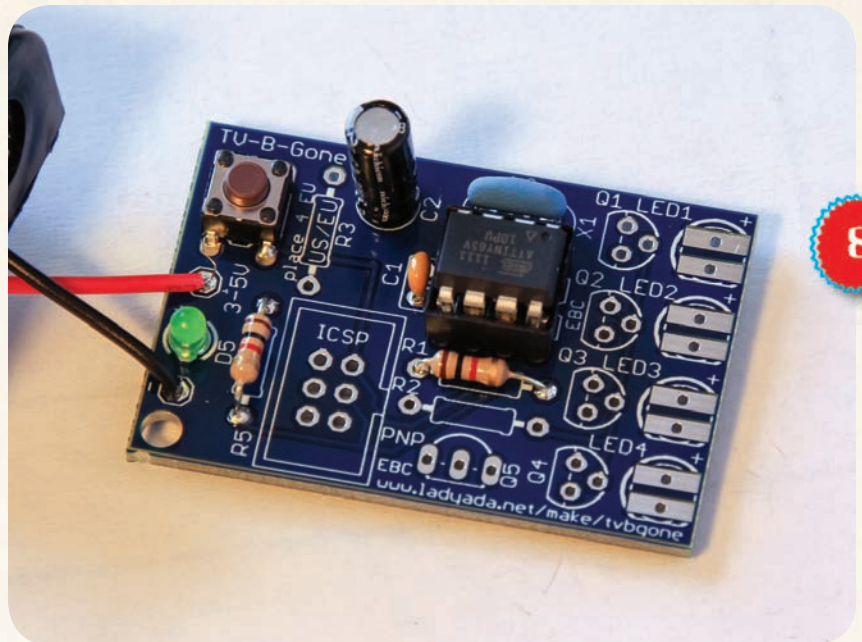
### NOW ZAP THAT TV!

That's it — you're all done. Take your TV-B-Gone anywhere you need to zap a TV; just point and press. It automatically transmits the "Off" code for just about every TV made on Earth!

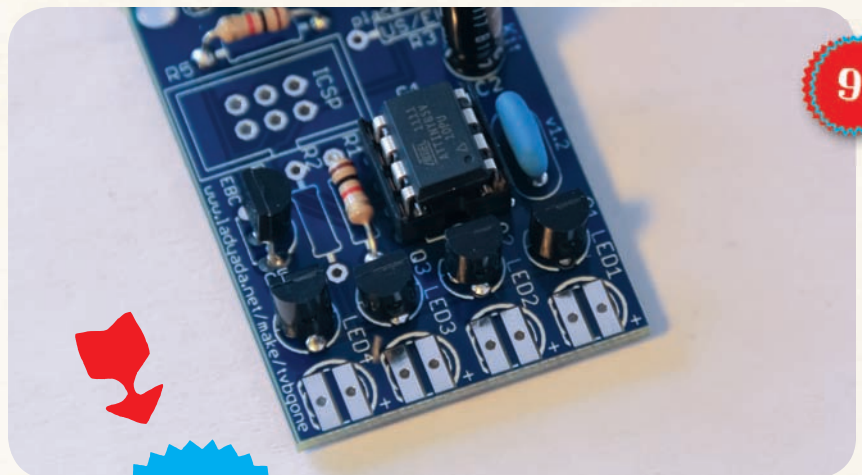
You can enclose it in a small case, or else install it in your clothing for covert use. To make a stealthy TV-B-Gone zipper jacket or baseball cap, see [makeprojects.com/project/t/48](http://makeprojects.com/project/t/48) and [makeprojects.com/project/t/60](http://makeprojects.com/project/t/60). Enjoy!

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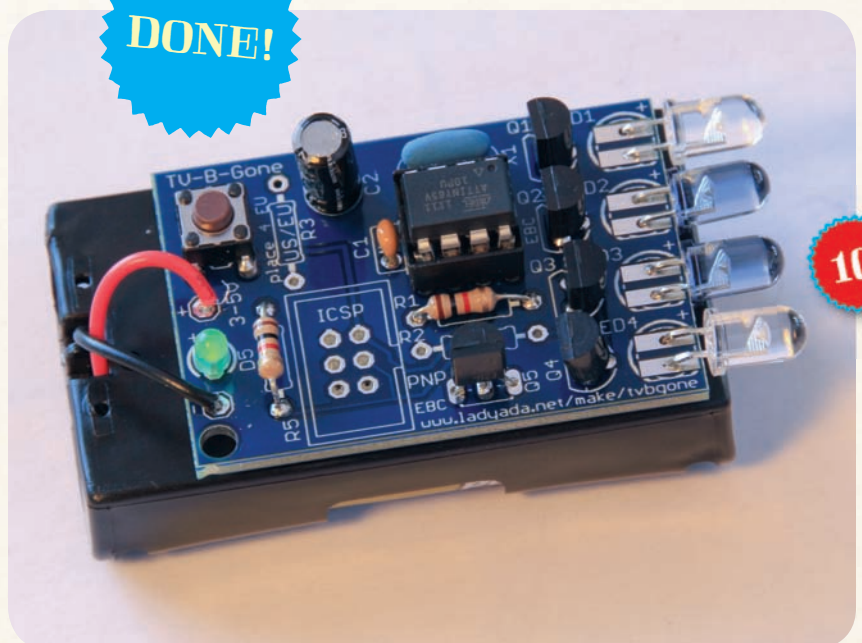
Nick Brenn is studying electrical engineering at Union College. His research interests include nanotechnology, renewable energy, and the scanning electron microscopy of roasted coffee beans. He demonstrated his upcycled Altoids LED Flashlights on Anderson Cooper's talk show.



8

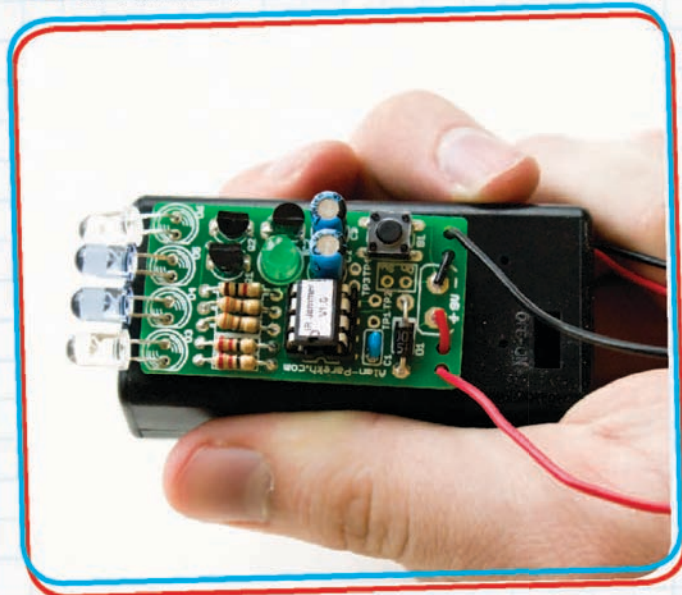


9



10





# REMOTE CONTROL JAMMER KIT

12 & UP

»» Don't want anybody changing your channel? With the click of a button, you can **block all IR remote controls** for TVs, DVDs, you name it. This jammer kit uses a microcontroller chip to target all six main IR frequencies! You'll solder the chip socket, infrared LEDs, and other components onto a small printed circuit board (PCB), then hook up the 9V battery pack.



## SIMPLE LASER COMMUNICATOR

12 & UP

Talk in secret over your own laser beam light link! It's completely private, with no wire connections for enemy spies to tap into. Use a cheap laser pointer and a few parts from RadioShack to set up your transmitter and receiver using either a photoresistor or a small solar cell, and some simple soldering.



## EVASIVE BEEPING THING

12 & UP

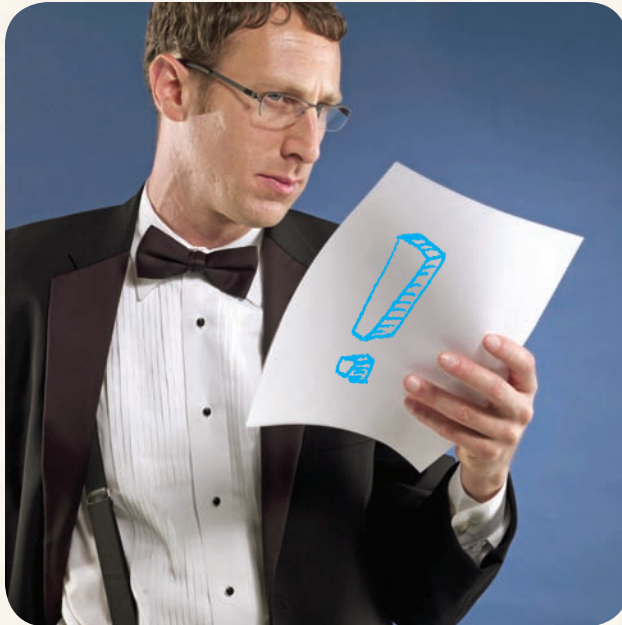
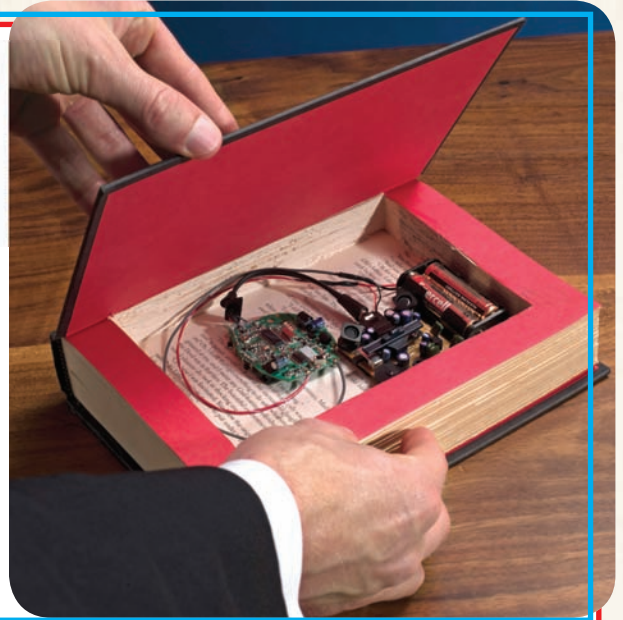
Drive your frenemies insane! This infernal noisemaker emits a 5-second beep every few minutes that's so high-pitched they can't tell where it's coming from. Solder the simple circuit using a 555 timer chip, a small speaker, and a few resistors, transistors, and capacitors.



## COVERT WIRELESS LISTENING BUG

12 & UP

Connect an “amplified listener” hearing aid to an in-car FM transmitter (like for iPods), and you’ve got a wireless bug. Tuck it inside a hollowed-out book and you can leave the bug near your surveillance target and eavesdrop through your FM radio in the next room!



## INVISIBLE INK PRINTER

ALL AGES ADULT SUPERVISION

Got a top-secret message to send? Lemon juice has been used as invisible ink for centuries — now you can update the technique by putting the juice in an inkjet printer cartridge. Print your invisible documents from the computer, then brush them with a special iodine solution to see the message.

## TALKING BOOBY TRAP

12 & UP

Villains snooping in your room? Snatching your secret stuff? Catch them red-handed with this easy gizmo — just record your message on a ready-made voice module, and solder 2 connections to a clothespin that acts as the switch. When it’s disturbed, the intruder will get a surprise talking-to.









# SCHOOL'S OUT: FLIGHT



As the weather clears up, the blue sky is just begging for some rockets. Leo helps Josh make a compressed-air launch pad, and Ella shows them how to make paper and foam rockets to match. They start shooting the rockets off in a big field at Ragle Ranch Park, and a crowd gathers around when they see how incredibly high their little disposable rockets can fly. 3, 2, 1, blast-off! ➡



ALL AGES ADULT SUPERVISION

# COMPRESSED AIR ROCKETS

FAST, CHEAP, AND AMAZING. BY RICK SCHERTLE

Building this rocket launcher is a breeze, and folks are always amazed at how it shoots reusable paper rockets 200–300 feet high.

The launcher is made from PVC pipe. You pressurize its chamber to 75psi with about 18 strokes of a bicycle pump, then release all the pressure in a split second through an electric sprinkler valve, sending the paper-and-tape rocket into the sky.

Older kids can do the soldering, and adults should be on hand to supervise the launches, but kids of any age can make the rockets and launch them. It's mind-blowing how high they go.

**CAUTION:** Wear gloves and work in a well-ventilated area when gluing PVC.

## BUILD YOUR LAUNCHER

**1.** To build the **pressure chamber**, wrap Teflon tape around the  $\frac{1}{2}$ " $\times$  $\frac{1}{4}$ " brass bushing threads and screw it into the 2" $\times$  $\frac{1}{2}$ " threaded PVC bushing, tightening with an adjustable wrench. Screw the hose barb into the brass bushing, and cement this assembly into one side of the 2" tee.

On the other side of the tee, glue in the 10" pipe, and cap it by gluing on a 2" end cap. Glue the 2" $\times$  $\frac{3}{4}$ " slip bushing into the middle of the tee.

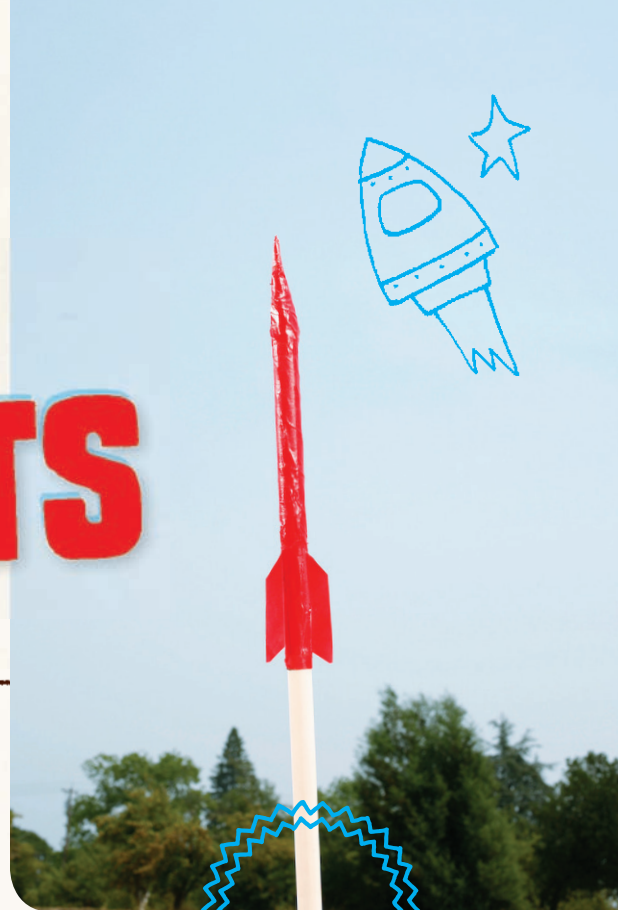
**TIP:** To glue PVC connections, first wipe the contact surfaces with PVC primer, then wipe with glue, and twist the parts together to mate them, working quickly.

**2.** For the **valve system**, wrap Teflon tape around the threads of the  $\frac{3}{4}$ " MPT (male pipe thread) to  $\frac{3}{4}$ " female slip adapters, then screw them into each side of the sprinkler valve and tighten with pliers.

Note the arrow directions on the valve. On the "in" side, glue in a  $\frac{3}{4}$ " $\times$ 3" pipe. On the "out" side, glue in a  $\frac{3}{4}$ " $\times$  $\frac{1}{2}$ " slip reducer and then a  $\frac{1}{2}$ " $\times$ 13" pipe, and use a file to bevel the other end of the pipe.

Glue the "in" side pipe into the slip bushing in the middle of the pressure chamber tee to connect the 2 assemblies.

**3.** To make the **stand tubes**, drill a pair of  $\frac{1}{4}$ " holes completely through each remaining  $\frac{1}{2}$ " $\times$ 13" pipe, centered about 2 $\frac{3}{4}$ " apart. Then thread one large zip tie through the holes in each tube, so that the ties can zip around the pressure chamber later. Leave the ties open for now.



Gabriela Hasbun (top); Gunther Kirsch



## MATERIALS

Get the **MAKE COMPRESSED AIR ROCKETS KIT** from Maker Shed (item #MKRS1 at [makershed.com](http://makershed.com)). Or you can buy all the parts yourself at the hardware store. For a complete materials list, go to [makezine.com/go/airrockets](http://makezine.com/go/airrockets).

### ADDITIONAL ITEMS NOT IN KIT:

BICYCLE PUMP  
TIRE PRESSURE GAUGE  
9V BATTERIES (2)  
PVC PRIMER AND CEMENT  
TEFLON TAPE

ELECTRICAL TAPE OR HEAT-SHRINK TUBING  
DUCT TAPE

### TO MAKE THE PAPER ROCKETS:

PRINTED ROCKET TEMPLATE

Download and print from [makezine.com/go/rockettemplate](http://makezine.com/go/rockettemplate).

CLEAR PACKING TAPE OR MASKING TAPE:

$\frac{3}{4}$ " WIDE, 2" WIDE

PAPER NAPKIN

GLUE STICK

## TOOLS

ADJUSTABLE WRENCH

CHANNEL-LOCK PLIERS

SOLDERING IRON AND SOLDER

SCREWDRIVER

WIRE CUTTERS AND STRIPPERS

DRILL AND BITS:  $\frac{1}{8}$ ",  $\frac{1}{4}$ ",  $\frac{1}{2}$ "

RUBBER Mallet

FILE

SCISSORS

PENCIL

HACKSAW OR PVC CUTTER, AND RULER  
(OPTIONAL) if you're cutting the pipe pieces

SAFETY GLASSES OR GOGGLES

GLOVES



**5.** For the **power supply**, solder the red wire from one battery clip to the black wire of the other; trim the wires for neatness and insulate the connection.

Solder either free battery wire to either sprinkler valve wire, the remaining battery wire to either speaker wire, and the remaining speaker wire to the remaining sprinkler valve wire. Insulate the connections and then load 9V batteries in the snaps. When you press the button now, you should hear the sprinkler valve click.



**4.** The **launch handle** lets you fire rockets from a safe distance. Drill a  $\frac{1}{8}$ " hole in one of the  $\frac{3}{4}$ " end caps and a  $\frac{1}{2}$ " hole in the other. Solder the pushbutton contacts to the speaker wires, insulate the connections with tape or heat-shrink tubing, and mount the button in the  $\frac{1}{2}$ " hole, facing out. Tie a loose knot in the wire about 8" from the button.

Fit this cap over the 4" pipe, then thread the speaker wire through the other cap and fit it onto the other end, with the knot inside the tube (to prevent pulling on the solder joint). Do not glue.



**6.** To connect the **air supply**, use 2 pairs of pliers to twist the rubber sheath off the tire valve, being careful not to crush it. Fit the exposed end into one end of the vinyl tube, and secure it with the hose clamp by tightening the screw. Fit the other end of the tube over the hose barb on the pressure chamber.





7. Finish up by wrapping the air chamber with several layers of **duct tape**. This is for safety, to contain any shards of PVC in case the launcher cracks under internal pressure.

Finally, tighten the large **zip ties** on the stand tubes around either end of the pressure chamber, and use another large zip tie to attach the batteries on top.

8. Attach the bike pump to the valve and **test the system** by pressurizing it to about 75psi. If you find leaks, fix them and try again.



## MAKE YOUR ROCKETS

9. Download and print the rocket template on 8½"×14" paper. Cut out the pieces, and decorate if desired.

Wrap the **body tube** around a 10½" pipe and tape it smoothly in 5 places with ¾" tape. Fully wrap the tube with 2" tape (use clear tape to let any decorations show through), working your way down and making it about 2 layers thick.

10. Slide the tube to one end of the pipe and tape the **pressure cap** on by crisscrossing ¾" tape over the top, 2 layers thick, and smoothing it down.

11. Curl the **nose cone** to overlap the dotted section, tape it together, and use a pencil to pack it tightly with a paper napkin.

Tape the nose cone on top of the body tube using the tabs, then cover it in tape.







**12.** Wrap the fin guide around the base of the body tube and use it to mark the tube for either 3 or 4 fins.

Fold the **fins** on the dashed lines, stack them together, and trim the ends at an angle. Glue the fins together with a glue stick (don't glue the tabs), line them up at your marked locations, and tape them all securely in place.

Your rocket is now complete and ready to launch!



## NOW LAUNCH SOME ROCKETS

Place the launcher up on a raised surface so the launch tube is above eye level. Lay out the air hose and trigger wire away from the launcher.

Slide the rocket down the launch tube until it stops at the pressure cap. Connect the bike pump to the hose, put on your eye protection, and pump it up to about 75psi. (If you go above 75psi, you may blow out the side of your rocket.)

Count down, and then launch! With a good launch, the rocket will go nearly out of sight and then free-fall to the ground. The rocket will crumple as it hits the ground, but you can simply pinch it back into shape and launch it again and again.

**+** Download and print the rocket template from [makezine.com/go/rockettemplate](http://makezine.com/go/rockettemplate).



**CAUTION:** Compressed air can be dangerous, so wear eye protection when the launcher is under pressure.

Standing clear of the pressure chamber, press the launch button. If the pressure doesn't release, tighten down the solenoid (the black thing with the wires coming out) on the sprinkler valve. If you're still having problems, most valves have a manual trigger that you can flip to release the pressure. But if you're up this close, you should wear hearing protection as well, and of course keep your head away from the launch tube.

Rick Schertle ([schertle@yahoo.com](mailto:schertle@yahoo.com)) is a master of the craft of teaching middle school in San Jose, Calif., and a novice maker at home. His diverse interests include backyard chickens, adventure travel, veggie oil-fueled cars, and geocaching — all made more fun with the enthusiastic support of his wife and the crazy antics of his young son and daughter.

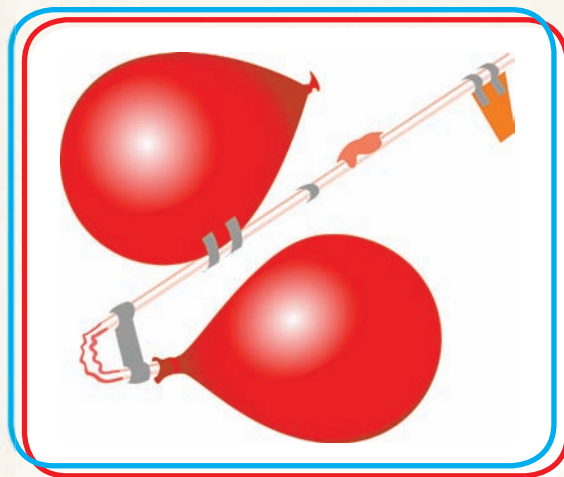




# SODA BOTTLE WATER ROCKET

ALL AGES ADULT SUPERVISION

»» Build a **high-performance water rocket** out of 2-liter soda bottles and PVC pipe — complete with parachute. You pump it up to 70psi with a bike pump, then the compressed air forces a jet of water out, producing thrust and sending the rocket up hundreds of feet.



## EASY BLIMP

ALL AGES FUN FOR GROUPS

Make a blimp from balloons and straws and fly it around the house! A helium balloon provides the lift; a balloon full of air provides jet propulsion; and a gob of clay provides the ballast (so it doesn't just float up to the ceiling or the sky).



## \$4 HOT AIR BALLOON

12 & UP ADULT SUPERVISION

Use a cheap painter's drop cloth and clear tape to make a real hot air balloon, then build a burner to inflate it and fly it on a tether (on calm days only, please). It's even strong enough to fly a tiny digital camera.



## FOLDING WING GLIDER

ALL AGES

Fold this balsa glider's wings back and slingshot it high into the air. When the glider reaches its peak, its wings pop open for a long, graceful flight down. Newly remanufactured from a classic design, these gliders are far more durable and fun than cheap balsa planes.

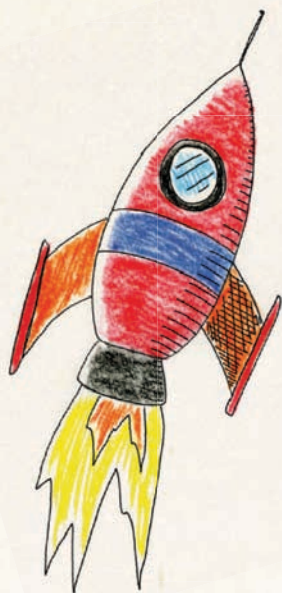
GET THE KIT  
AT MAKER  
SHED.COM/  
GLIDER



## HELIUM BALLOON IMAGING "SATELLITE"

12 & UP

Snap aerial photos from 300 feet up by suspending a hacked drugstore digital camera from three tethered helium balloons. You'll solder the circuit and program a tiny \$3 microcontroller chip to tell your camera when to snap. The pictures are better than Google Earth!



## \$5 HELICOPTER ROCKET

12 & UP ADULT SUPERVISION

Use toilet paper tubes, coat hangers, rubber bands, and hobby rocket motors to build a high-flying model rocket that transforms into a helicopter mid-flight, then spins dramatically back down to Earth.











## SCHOOL'S OUT: **ELECTRONICS**



On a visit to their local makerspace at MAKE Labs, the crew learn about free software that converts digital photos of any object into a 3D model you can print out on one of those amazing 3D printers. They try it out, creating mini models of their heads and printing them on a MakerBot. It's impossible not to stare at the 3D printer as it builds up your head, layer by layer! The kids are inspired by the cool tools and helpful experts at the makerspace. A robot project is next on their list! ➡



# PRINT YOUR HEAD IN 3D!

USE DIGITAL PHOTOS AND A 3D PRINTER TO MAKE A MINI PLASTIC REPLICA OF YOUR NOGGIN. BY KEITH HAMMOND



Here's a great project to get you started in 3D printing — create a 3D model of your own head and then print it out in solid plastic!

A 3D printer makes an object by squirting out a tiny filament of hot plastic, adding one layer at a time. That's why it's called *additive manufacturing*. You send the printer a computer file that's a 3D model of something — an iPod case, a bike part, your head — then it prints out the object for you. These machines are becoming affordable for schools, labs, libraries, and families, and there's lots of software out there for creating 3D files to print.

We chose Autodesk 123D software for this project because it's free, a

lot of it is web-based so you can use it from any computer, and amazingly, it lets you create a 3D model directly from digital photos. That way, you can do it all from home, and you don't have to go get yourself scanned by a laser scanner.

When you're done making your 3D model, you can take it to a maker-space where they have a 3D printer, or you can send it out to a service and they'll print it and mail it right to your home. We printed our heads on a MakerBot Thing-O-Matic printer, using ReplicatorG as the printer software. It was easy!

Imagine what else you could 3D-print with these tools. Instead of your head, why not action figures of your whole self, dressed as a hobbit or vampire or Imperial stormtrooper? Or make models of your pets, the family car — almost anything you can capture in photos.

## TOOLS

COMPUTER WITH INTERNET ACCESS  
AND WEB BROWSER

MESHMIXER SOFTWARE (OPTIONAL)  
free from [meshmixer.com](http://meshmixer.com)

3D PRINTER AND COMPUTER WITH  
PRINTER'S SOFTWARE (OPTIONAL)

If you don't have access to a 3D printer, you can send your 3D model to a service instead, and they'll print and mail it to you (see Step 10).





## 1. REGISTER WITH AUTODESK 123D

Go to [123dapp.com](http://123dapp.com) and create a free account. For this project, we'll use the web apps for 123D Catch and 123D Sculpt. (See page 10 for a fun project using 123D Make.)

If you want to send your finished 3D model out to be 3D-printed for you, you can just use the web app of 123D Catch. But if you want to download your model so you can 3D-print it yourself, you'll need to use the desktop version of 123D Catch (free, for PCs only).

## 2. TAKE DIGITAL PHOTOS OF YOUR HEAD

You'll want a friend's help with this part. You can use a cellphone camera or a nice DSLR — the better the camera, the better 123D Catch will work. Shooting in full shade works best.

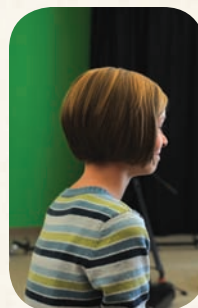
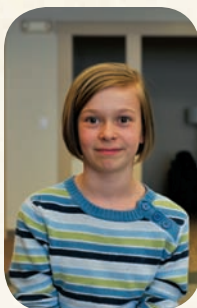
Sit still while your friend snaps 30 or 40 photos of your head, in 2 separate loops moving completely around you — one lower loop, and one higher loop where the top of your head is seen clearly. This will prevent unwanted holes in your head where the software is missing part of the scene. For best results, make sure your head fills most of the frame.

If you're going to stick out your tongue or make a face, ask your friend to work fast so you can hold your expression. But remember to keep the camera still and focused when snapping each photo, because blurry images may confuse the software and cause weird horns on your head.

## 3. CREATE A NEW CAPTURE

In 123D Catch (web or desktop), upload all your head photos. You can select Standard quality for your 3D model.

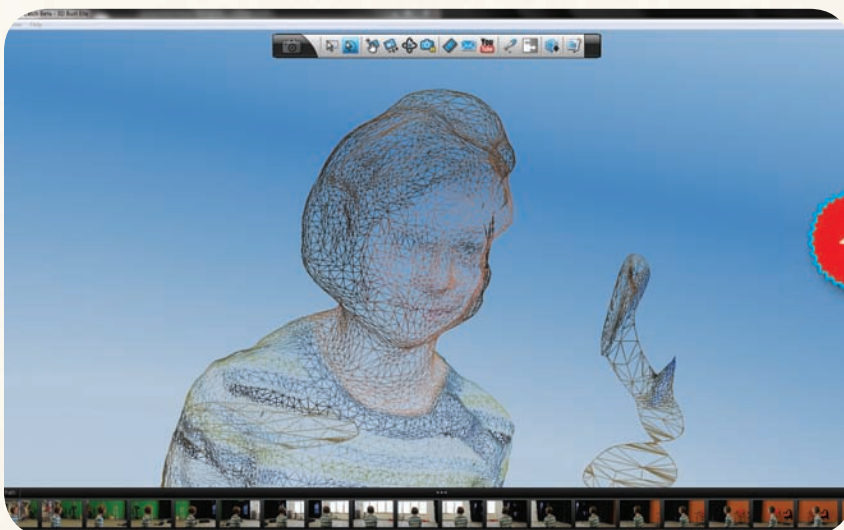
Autodesk's computers will automatically stitch all your photos together to make a 3D model, and then put the model in your My Corner section (or email it to you if you're using the desktop version).



2



3



4

## 4. OPEN YOUR 3D MODEL

You're looking at yourself as a 3D model! It's got a realistic texture, like your original photos. You can Dolly, Pan, and Orbit to move your view around, by using those 3 buttons on the toolbar.

Click the globe icon (or the cube icon in the desktop version) to see the 3D mesh underneath the texture. Cool!

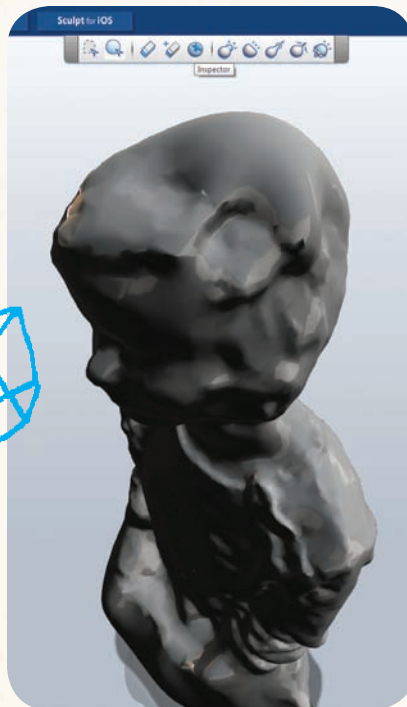
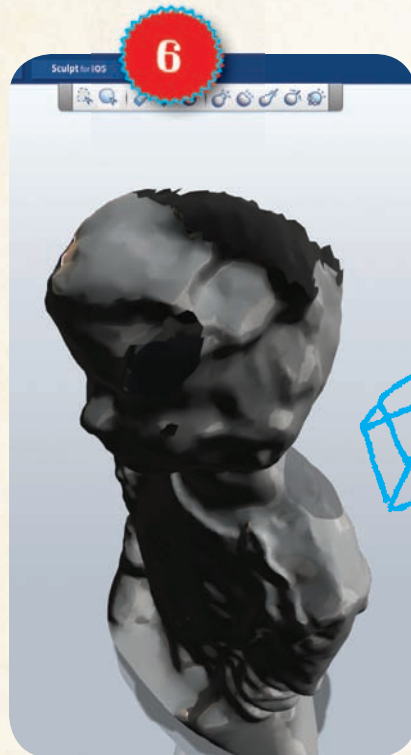




## 5. EDIT YOUR 3D MODEL

In my first model, I had a crazy horn on the back of my head, probably because we took some photos that were blurry or too far away. It's easy to remove unwanted features — just click the Lasso button, then lasso and delete them. But be careful! You can't undo this.

Trim your model to size and save it under a new name.



## 6. MAKE IT "WATERTIGHT"

In My Corner, open your 3D model and click the Sculpt It button at the top of the window. Now you're in the 123D Sculpt web app. Use the Lasso or Paint tools to select bits you'd like to delete, then click the eraser icon (Discard Selection) to delete them.

Now click the Inspector tool to automatically repair any holes. The big hole at the bottom of your neck might now be an extended blob. Use the Lasso or Paint tools to highlight the unwanted blob, then click the eraser, then click Inspector again. This should cut it down to size.

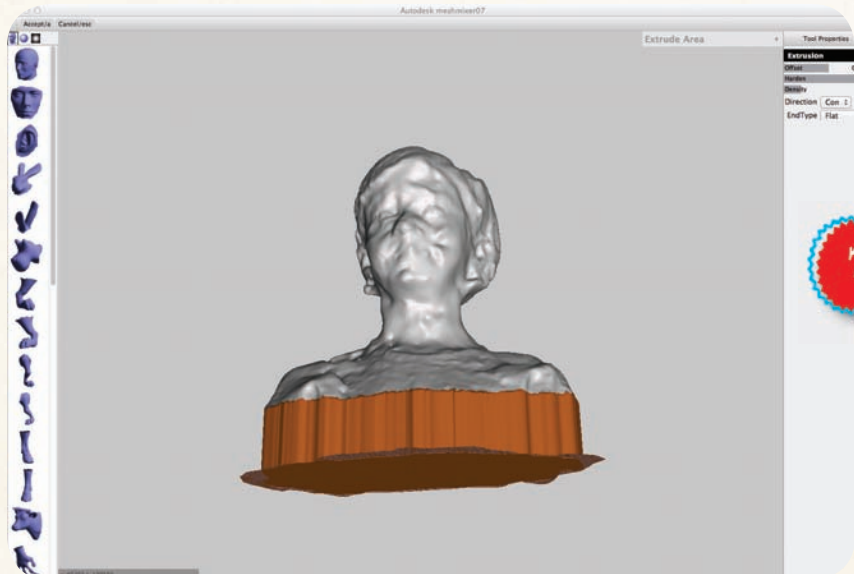
Re-save your model to My Corner.

If you're printing your own head, export your model from 123D Catch (desktop) as an OBJ file, then do this same process in MeshMixer software instead (free from [meshmixer.com](http://meshmixer.com)).

## 7. PUT IT ON A PEDESTAL (OPTIONAL)

For best results on the 3D printer, your model should be flat on the bottom. You don't absolutely need to do this step (a 3D printer's software can prop your head up for printing), but it makes a much nicer permanent object. (If you're sending your head out to be printed by Autodesk, you can skip this step.)

In MeshMixer, use the Select tool to slice off the bottom of your model, then choose the Extrude tool. In the Tool Properties bar on the right, set the EndType to Flat. Then just click and drag the bottom surface of your





model to extend it, creating a simple pedestal that's perfectly flat!

You can also use MeshMixer to merge your head with a fancy pedestal. Select the whole mesh, choose Edit → Convert to Part, and click Accept. Look at the Parts bar on the left: your head is now a “part” that you can merge with other parts.

Go to Thingiverse ([thingiverse.com](http://thingiverse.com)) and grab an STL file of a pedestal. Open the pedestal in MeshMixer, then drag your head onto it to merge the two. If it doesn't work the first time, try “remeshing” both parts by selecting Edit → Remesh. Save your merged model as a new STL file.

You can do lots more with MeshMixer. Put an arrow through your head, or stick octopus tentacles on it, or make yourself a two-headed monster. Or put your head on a Pez candy dispenser!

## 8. SHARE YOUR MODEL (OPTIONAL)

In the web app: When your model is done, click on Publish to Gallery. Now anyone can open it in a web browser and play with it.

In the desktop version: Make a video animation and send it straight to YouTube!

## 9. SAVE YOUR FINAL MODEL AS A PRINTABLE FILE (OPTIONAL)

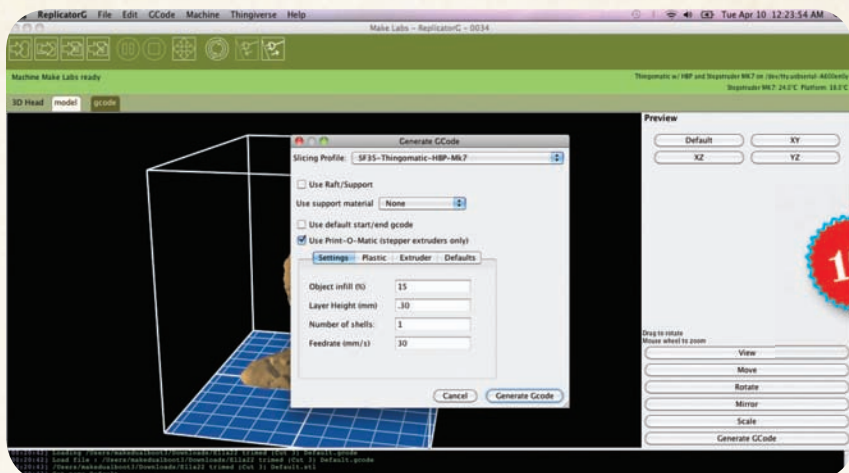
To print your own head, you need a copy of your 3D model in a format that 3D printers can understand. Export your model from MeshMixer as an STL file. (Fun fact: STL stands for *stereolithography*, which is a different type of 3D printing.)

If you're sending your head out to be printed by Autodesk, you can skip this step.

## 10. 3D-PRINT YOUR HEAD!

Find the nearest makerspace, hackerspace, or other place where you can use a 3D printer (see directories at [makerspace.com](http://makerspace.com) and [hackerspace.org](http://hackerspace.org)). Bring your STL file on a thumb drive.

We printed our heads on a MakerBot Thing-O-Matic, which we



like because it automatically prints objects one after the other — and because you can buy it as a kit and build it yourself.

First, you'll open your STL file in the 3D printer's software, which tells the printer exactly where to make trails with the hot plastic to build up your object. If your printer uses ReplicatorG software, import your STL file, center the model and put it on the platform, then scale it to your desired size. Next, click Generate GCode, select the default print profile, and check the Use Print-O-Matic checkbox. Now hit Print.

Watch in amazement as your head materializes before your eyes!

If there's no 3D printer close by, that's OK — there are lots of service

companies that will print out your 3D model for you. In My Corner, click Fabricate Online to send your file to Autodesk's digital fabrication service and receive your 3D-printed plastic head in your mailbox. It costs only about \$10 for a 3"-tall head.

Or try sending your file to Shapeways ([shapeways.com](http://shapeways.com)) or Ponoko ([ponoko.com](http://ponoko.com)), or in Europe, try Sculpteo or i.materialise. Some of these services will even print your head out in ceramic, glass, steel, silver, gold, or titanium!

123D tutorial videos from Autodesk: [youtube.com/123d](http://youtube.com/123d) and [123dapp.com/catch/learn](http://123dapp.com/catch/learn)

Keith Hammond is projects editor of MAKE.

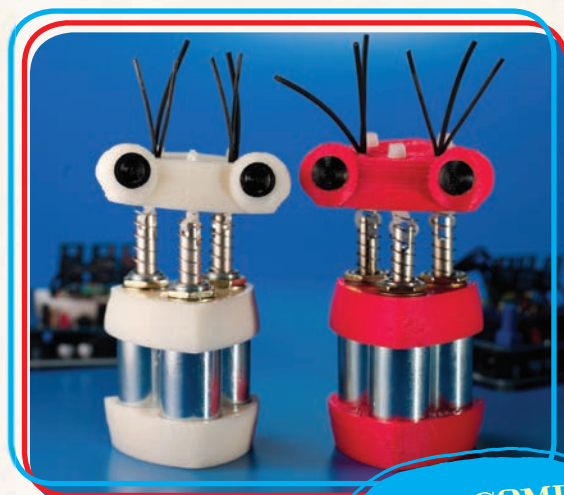




# SECRET KNOCK GUMBALL MACHINE

12 & UP

»» Only you know the secret code with this brainy **candy dispenser**. A piezoelectric sensor detects knocks while the Arduino Uno acts as gatekeeper. But it's not just for candy: what else could you unlock with a secret knock?



## SPAZZI THE DANCEBOT

12 & UP

This little Arduino-powered robot dances at the touch of your keyboard, or to the beat of music on your computer. Build up your Arduino skills by using the MakerShield prototyping board, and use a 3D printer to print out Spazzi's head and body.

HOW COME MORE ROBOTS DON'T DANCE?



## MOST USELESS MACHINE

12 & UP

What's more useless than a machine whose sole purpose is to turn itself off? Solder a simple circuit with a switch and motor, and design your case out of wood or laser-cut acrylic. Makes a great prank for your friends.



## LED HULA HOOP

ALL AGES ADULT SUPERVISION

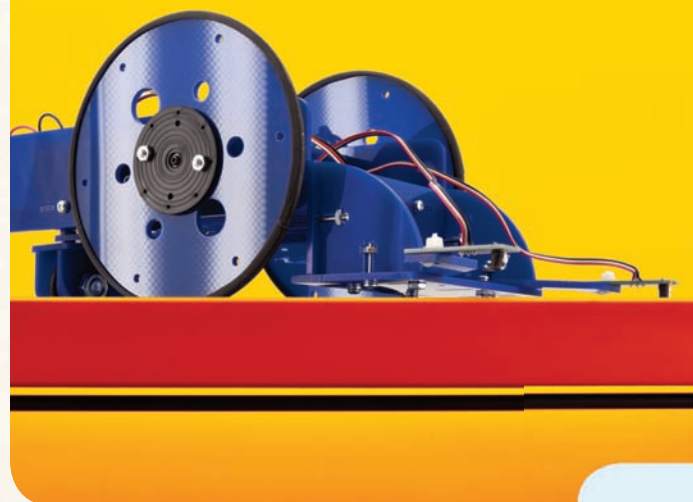
Wow your friends and show off your dancing skills with your very own light-up hula hoop! Use the basic circuit schematic or design your own, and solder a ton of LEDs.



## TINY WANDERER ROBOT

12 & UP

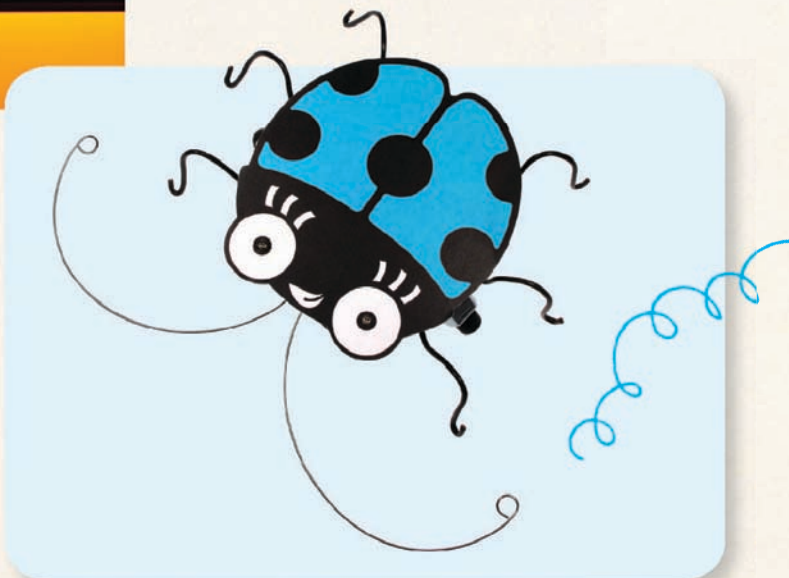
This project is perfect for beginning roboticians. You'll learn to program an ATtiny85 chip and modify the chassis for three different behaviors: edge detection, line following, and object avoidance. Upgrade your robot with Arduino and let your imagination wander!



## BEETLEBOT

ALL AGES ADULT SUPERVISION

One of the simplest robots you can make, the BeetleBot avoids obstacles using switches and motors: no programming required! Use basic soldering skills to build a simple circuit and watch your creation explore the world. Get the kit at Maker Shed ([makershed.com](http://makershed.com)).









# SCHOOL'S OUT: WEIRD SCIENCE



Those depressing “back to school” commercials are on again (hey, don’t remind us!), but there’s still time for fun. Looking ahead, the kids decide to do some “weird science” experiments that they can trot out during the school year for easy extra credit. For starters, they cook up a batch of Kryptonite Kandy that glows an eerie green under ultra-violet light. Bonus: It also makes your pee green! That’s science, right? ➡



# KRYPTONITE KANDY

IT GLOWS!  
BY BECKY STERN

ALL AGES  
ADULT SUPERVISION

Using just a few ingredients, you can make Kryptonite Kandy, a sweet treat that glows an eerie fluorescent green under ultraviolet light.

## COOK YOUR CANDY

**1.** First, gather your ingredients: sugar, Electric Green food coloring, your favorite flavored oil, and vitamin B2 capsules — the magic touch that makes the candy fluoresce. You'll also need a stove, heavy pot, whisk, candy thermometer, aluminum foil, quartz crystals to make the molds, and some dry rice in a pan to hold up the molds.

**2.** Before cooking, prepare your molds by covering the quartz crystals in aluminum foil, then carefully pulling the foil apart, leaving an impression. You can also make long strips of candy by folding the foil lengthwise and curling up the ends so the candy doesn't leak out.

Set your molds into the pan of rice to maintain their shape.





## MATERIALS

SUGAR, 1¼ CUPS

WATER, ⅝ CUP

VITAMIN B2 CAPSULES (3) You can also use solid tablets if you grind them into a fine powder first.

FOOD COLORING, AMERICOLOR  
ELECTRIC GREEN SOFT GEL PASTE

FLAVORING OIL Mint or apple will match the green color.

## TOOLS

MEASURING CUP, CUP, LADLE,  
HEAVY POT, WIRE WHISK, BAKING PAN

CANDY THERMOMETER

QUARTZ CRYSTALS or other  
kryptonite-shaped form

UV FLASHLIGHT

RICE

STOVE



**3.** In a cup, empty 3 capsules of vitamin B2 into ⅝ cup of water, and stir to dissolve. Measure out 1¼ cups of sugar, and combine it in the pot with the B2/water mix.

**4.** Set the pot over low heat and mix the sugar to dissolve, monitoring the solution's temperature with the candy thermometer. Cook slowly to avoid scorching the sugar.

When the solution reaches 200°F, stop mixing and wait for the temperature to reach 300. Remove the pot from the heat immediately.

**CAUTION:** Hot molten candy can cause serious burns. Cook this up with adult supervision only.

**5.** Now it's time to work fast. Add your food coloring and flavoring and quickly stir, then ladle the mixture into your molds.

**6.** Wait until the candy has solidified, and carefully pull the pieces from the molds by tearing away the aluminum foil. You can also break the larger pieces up into smaller pieces.

To check that the candy glows, put it to the test under the UV flashlight. Congratulations, you've made UV-sensitive Kryptonite Kandy. Enjoy!

Serve your Kryptonite Kandy at a party under a black-light bulb or with the UV flashlight. It's a fun, spooky treat for Halloween. To keep the candy glowing its brightest, store it in an opaque container.

*This project is originally by BrittLiv on Instructables ([instructables.com](https://www.instructables.com)).*

Becky Stern is head of the wearable electronics group at Adafruit Industries.

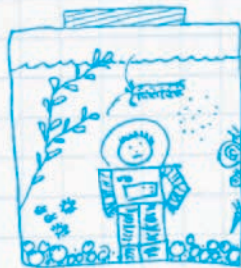




# TABLETOP BIOSPHERE

ALL AGES

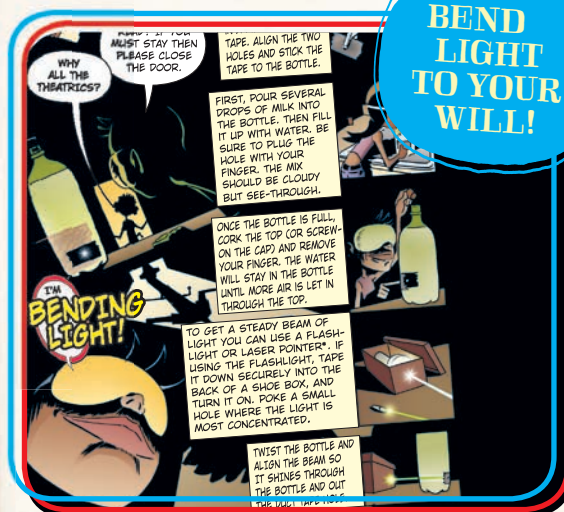
»»» Become the master of your own tiny universe complete with a freshwater shrimp “econaut” and a cleaning crew of snails. Collect mud, rocks, and plants, seal it all in a jar, and your **mini ecosystem** is good for 3 months. Observe and take notes like a real scientist.



## ANIMAL DETECTOR

12 & UP

Ever wonder what furry friends are scurrying about outside while you're sleeping? Catch them in the act using the webcam on your computer and motion-detecting lights and software. Each morning, you'll have pictures of the animals who came to visit.



## BENDING LIGHT

ALL AGES

Light travels in straight lines, but you can get it to bounce around a bend with a little science! Using a plastic bottle, some duct tape, liquid, and a flashlight or laser pointer, you can watch the glow flow.



## VAN DE GRAAFF GENERATOR

12 & UP

Impress your friends and fellow citizen scientists by shooting electrical sparks. A mini motor drives a rubber belt around a glass roller, creating a negative charge. A metal brush transfers the charge to a soda can, which stores it. Put your finger close to the can to generate bright 3" sparks!



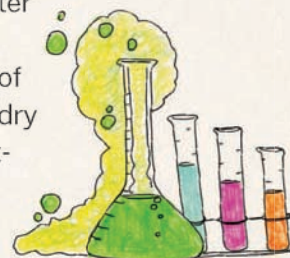
PEEP  
COSMIC  
RAYS!



## CLOUD CHAMBER

ALL AGES

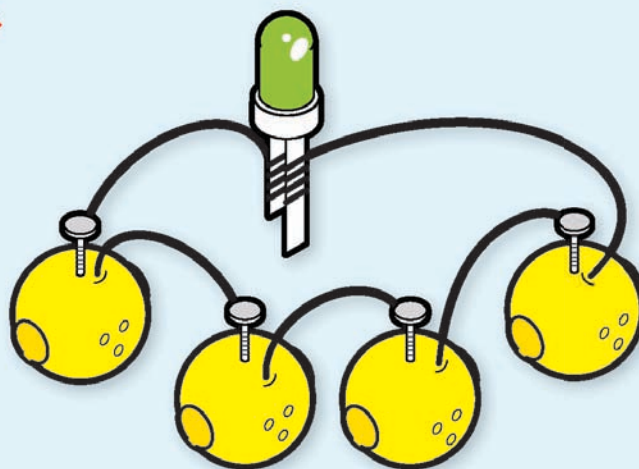
Want to see what sub-atomic particles from outer space look like? You can catch the ghostly tracks of these cosmic rays using dry ice, alcohol, and a basketball display case.



## BATTERIES FROM EVERYDAY THINGS

ALL AGES

Sneaky batteries are everywhere! Light up an LED using a lemon, or instead use a nickel, penny, and salt water. Only you will know the secret of how it's done.







# WHAT A SUMMER!

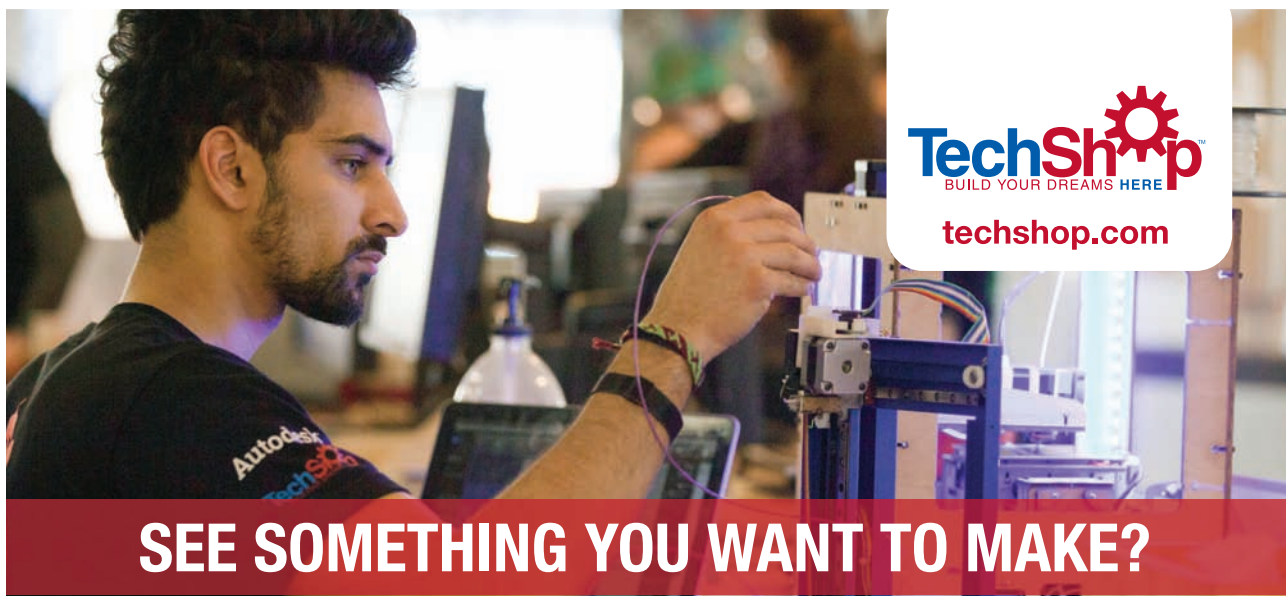
Nina, Ella, Josh, and Leo had such an awesome time making stuff they'd read about in **MAKE** magazine that they decided to send us a video. Check it out at [makezine.com/go/schools-out-video](http://makezine.com/go/schools-out-video).

We were so inspired by their video that we decided to encourage all of our readers to send us videos of projects they make!

Create something fun, make a video to show it off, have your parents post it on YouTube or Vimeo, and send the link to [editor@makezine.com](mailto:editor@makezine.com). In return, we'll share it with the world of makers on our website, and send you a \$15 gift certificate to the Maker Shed ([makershed.com](http://makershed.com))!

Remember, only adults can upload videos or make purchases on Maker Shed, and of course, anything defamatory, obscene, or objectionable will not be posted. Offer expires 12/31/2012. Only one gift certificate per family.





**SEE SOMETHING YOU WANT TO MAKE?**

**TECHSHOP HAS THE TOOLS YOU NEED.**

Want to learn how to weld, feel the power of a laser cutter, or create a 3D model using the latest design software? TechShop—a membership-based workshop and fabrication studio—offers access to over \$1,000,000 worth of tools and technologies for a low monthly fee. Stop in for a free tour from one of our highly trained staff or sign up for a class on our website. The possibilities are endless at **TechShop**. *Build your dreams here!*

A close-up shot of a hand wearing a blue nitrile glove holding a petri dish. The petri dish contains a green agar medium with visible bacterial colonies. The background is a light blue grid pattern.

# Join the DIY science revolution.

Make: Punk Science  
on newsstands July 24

# Make:

makezine.com



# HOW MAKER FAIRE CHANGED MY LIFE

BY BEN HYLAK

I've always loved computers. When I was six or so, I realized that instead of making all my Christmas thank you cards with crayons, I could do a mail merge — my mom says I've been hooked ever since.

At about 8 I started to rip apart old computers in our basement, for fun, and the challenge was to put everything back together and make it work better than before.

I spent the summer after 5th grade working on an old Tangerine iBook laptop I bought from eBay. At first, my dad said he thought it was pointless to dissect a perfectly good computer. My mom convinced Dad it was an education, and I could be doing a lot worse things with my time. I remember that Tangerine iBook like it was yesterday. It taught me tons. In my research on the ins and outs of that computer, I learned about the MAKE movement.

MAKE seemed like a whole new world to me. I felt like I had found people like me. I went to school, sure,

but that was not my support group. Sometimes it was just the opposite. Makers — their minds, the ideas swirling around, the junk turned into treasures, the energy of people who would enjoy turning an old laptop into something that could change the world — well, they inspired me. I would read their blogs, see what they were into, and I heard about the Maker Faire, and I wanted to go. Bad.

The first year I mentioned I would really love to go to the Maker Faire, I'm pretty sure my mom looked at me with a dead stare, wondering what I was even talking about. So I figured it was a "no" that year.

Then, in the fall of 2010, I came down with a very rare illness — the only reported pediatric case in the

world of what I had. I was in the hospital for weeks, didn't eat or drink a thing, and I guess it was looking pretty bad. I remember a blur, coming in and out of feeling too terrible to even want to be awake. My mom was there, and at one point, she asked me what was the one thing in the world I've always wanted to do but never did?

I told her I wanted to go to the Maker Faire ... it was such a nice thought in my head, all that "making" stuff; I wanted to feel that energy. It was the first thing that came to mind. I know my mom had no idea what I was talking about, but she looked it up and bought tickets to the 2010 NYC World Maker Faire from my hospital room. She told me later



Bridget Hylak



that when she pressed the “buy” button, she said a prayer I’d make it.

Well, I did! About six weeks later, we were in NYC. Even though I was still recovering, it was an awesome day. My friend Vincent came too. We both learned to solder there, and just in time, because I needed that skill to begin working on my science fair project — a telepresence robot named MAYA (“Me And You Anywhere”) that I had been dreaming about in my head and researching for about two years.

That science fair project turned out to be pretty successful! I won “best in show” in every fair I entered, and returned to the 2011 World Maker Faire as a featured presenter. My project won four Editor’s Choice Awards from Maker Faire officials.

Eventually, MAYA was entered into

the only available national science fair for middle schoolers, the Broadcom MASTERS Fair, and I was chosen as one of 30 National Finalists. The Broadcom program really gave me the incentive to keep improving my project and learning. I went to Washington, D.C., to compete for a week, and I wound up becoming the Broadcom MASTERS Silver Medalist in October 2011.

I was later chosen by the Society for Science and the Public to represent the Broadcom MASTERS program at the Presidential Science Fair at the White House in Washington! I was one of only a few kids allowed to personally present my project to the president.

Quite a trip from that hospital bed!

PS: I still love to solder!

## FUN FACTS

AGE: 14

LOCATION: PENNSYLVANIA

HERO: STEVE WOZNIAK

FAVORITE ACCOMPLISHMENT: BROADCOM MASTERS/WHITE HOUSE SCIENCE FAIR

FAVORITE TOOL: CNC MILL

CURRENT PROJECT: ARTIFICIAL INTELLIGENCE ROBOT

Maker Faire ... it was such a nice thought in my head, all that “making” stuff; I wanted to feel that energy.



Carrie Rowland (right)





## **Young Maker Profile:** **SYLVIA TODD**

Sylvia Todd's boundless enthusiasm shines through in everything she does. After attending the very first Maker Faire when she was 5, she says, "I began making (and destroying!) things." She learned how to solder from her dad when she was 7, and since the age of 8, she's had her very own show on the MAKE YouTube channel, "Super Awesome Sylvia's Mini Maker Show," where she demonstrates how to make everything from crazy putty to a no-heat lava lamp.

In addition to building projects, she enjoys reading novels and comic books, drawing, and riding her scooter. Sylvia also spends time sharing what she has learned with her younger siblings. "I taught my sister Talulah [age 8] how to lash two sticks together with a piece of long grass when building a fairy house," she recalls. "I love to see them make the same hilarious mistakes I used to make, but I get in there and help them out before they get too stuck."

Although she has a pretty sweet gig right now as a student and host of a fun internet show, she has even bigger dreams. What she wants to be when she grows up depends on her height, believe it or not. "If I stay short enough, aeronautical engineer/astronaut. If not, MythBuster!"

When asked how she would use her skills to solve one big world problem, she imagined a device to tackle world hunger: "FooderBot! A 3D printer that takes simple starches, sugars, and vitamins, then prints out nutritious, edible food."

Her fellow makers are her biggest inspiration, including "Ladyada (Limor Fried), the MythBusters, Bre Pettis, John Edgar Park, and everyone else I see out there showing off the awesome stuff they've made."

And for Sylvia, giving it a try is what it's all about. On her show, she tackles all projects with the same unwavering confidence, even those that can seem a bit daunting. Her advice is simple: "After you get out there and make something, don't give up! Failure is always an option. It really does happen, even to me!"

—Laura Cochrane

[blog.makezine.com/tag/superawesomesylvia](http://blog.makezine.com/tag/superawesomesylvia)

### **FUN FACTS**

AGE: 10

LOCATION: NORTHERN CALIFORNIA

HERO: MY DAD, TECHNINJA!

FAVORITE ACCOMPLISHMENT: BEING INVITED AND FLOWN TO BE PART OF MAKER FAIRE KANSAS CITY 2011, SCIENCE CITY ROCKS!

FAVORITE TOOL: LEATHERMAN SQUIRT (MAKE: CIRCUIT BREAKER)

CURRENT PROJECT: ONE MAKER SHOW PER MONTH AND AN ARDUINO-CONTROLLED HELICOPTER





## Young Maker Profile: **MARC-CHARLES MORQUETTE**

Marc-Charles Morquette loves exploring the inner workings of mechanical objects. Born and raised in Haiti until the age of 13, he began disassembling objects and trying to put them back together again at an early age. "I was always trying to fix appliances, engines, and gadgets that I would find around the house," he says. "My family thought I was crazy because every toy they would buy me, I would take apart to see how it worked. Understanding how things work allows me to make sense of my world. ... I constantly challenge why things are the way they are."

He remembers watching his father, an engineer, working on car engines and other projects. "One day, he asked me to help him," Marc-Charles recalls. "Since that very moment, I knew what it felt like to be a man! I knew I was going to be an engineer, just like my dad."

He's built everything from a lawnmower engine to an R/C airplane to a robot arm. At some point he wants to go back to Haiti to help his father build a bigger chicken-egg incubator for the small chicken farm he operates. Marc-Charles is also planning to build a go-kart and a four-motor drone helicopter.

A longtime fan of MAKE's YouTube channel, he first came across MAKE magazine while in high school, and it inspired him to build the Secret Knock Gumball Machine project. "I gathered a bunch of garbage components, then made it happen," he says.

Earning a solid B+ average in high school, Marc-Charles had hoped to get a scholarship to attend college — he's interested in mechatronics or robotic engineering. Although he got accepted to good schools, he didn't receive any scholarships, so he couldn't afford them. Undeterred, he is now studying engineering at a community college in Massachusetts, on a student loan, and juggling a 30-hour-a-week job.

As for the future? "One thing I know for a fact: I want to be my own boss one day," he says. "Meaning that I want to create or invent something that I become well known for. Just like Mr. Dale Dougherty, Mr. Bill Gates, or Mr. Steve Jobs."

—Laura Cochrane

### **FUN FACTS**

AGE: 19

LOCATION: LOWELL, MASS.

HERO: MY MOTHER, FOR GIVING ME THE BEST EDUCATION, AND MY FATHER, FOR INSPIRING ME WITH HIS ENGINEERING WORK SINCE I WAS 8 YEARS OLD

FAVORITE ACCOMPLISHMENT: I EARNED OVER 40 ACADEMIC, LEADERSHIP, AND SPORTSMANSHIP AWARDS DURING MY HIGH SCHOOL CAREER.

FAVORITE TOOL: LATELY IT'S THE ARDUINO UNO, BECAUSE IT HELPS ME LEARN ABOUT PROGRAMMING, WHICH IS A BIG CHALLENGE FOR ME.

CURRENT PROJECT: A MODIFIED BACKPACK WITH SPEAKERS, AN LCD SCREEN DISPLAY, AND SOME EL WIRE AROUND THE SIDE. I'LL USE AN ARDUINO UNO TO MAKE EVERYTHING WORK.





## Young Maker Profile:

# BRIAN CONWAY ↗

Eleven-year-old Brian Conway makes things that most boys only dream of: boats, air cannons, smoke bombs, nunchucks, rocket launchers, longbows, and a longboard skateboard, for starters. His projects are all parentally encouraged and supervised for safety, though his mom does worry about his penchant for projectiles.

"I read how you can mix toilet cleaner with aluminum foil in a plastic soda bottle, to create hydrogen gas that expands and then explodes the bottle," Conway says excitedly. "I couldn't resist! So I built an air cannon that shoots Gatorade bottles. They fit in it perfectly. I launch them and then they take about 30 seconds to explode."

Conway, a student at Norfolk Academy, got his first issue of MAKE magazine when he was 6 (the Spy Tech issue), and made his first project at age 7. "My mom wouldn't let me get an airsoft gun," he recalls, "so I drilled a hole in a pill bottle and stuck a pen in it to make an airsoft blowgun. I've been inspired by KipKay's projects for MAKE, and my dad inspired me to keep a notebook of all my projects so I won't forget them."

To pay for his projects, Conway also runs a small business mowing lawns in his neighborhood. "I just bought a Husqvarna trimmer," he says proudly. He loads his gear in a trailer and hauls it with the ride-on mower from job to job.

His dad helps out with some of his projects too. "My dad and I made a little one-person canoe about two weeks ago," Conway says. "A lot of people make them out of birch but we used plywood underlayment, screwed it together, siliconed the cracks, and then varnished it so it wouldn't rot."

Why make all this stuff instead of buying it? "You get a sense of pride knowing that you've made something," Conway explains thoughtfully. "It keeps your imagination running when you build stuff. If you run into a brick wall, you can get through it — you can problem-solve better."

—Keith Hammond

## FUN FACTS

AGE: 11

LOCATION: VIRGINIA BEACH, VA

HEROES: NIKOLA TESLA, CHARLES DARWIN (I WAS BORN ON DARWIN AND ABRAHAM LINCOLN'S BIRTHDAY)

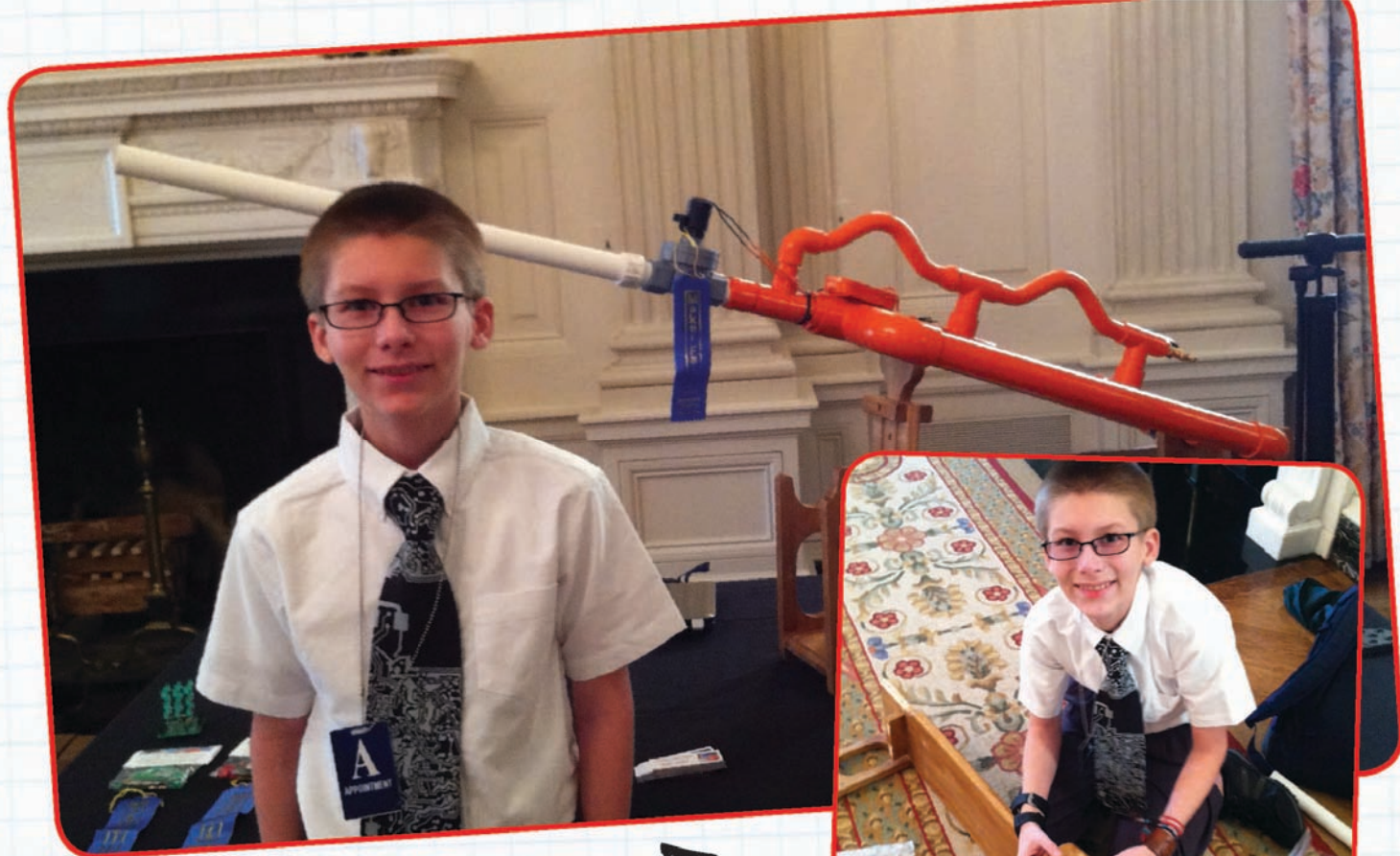
FAVORITE ACCOMPLISHMENT: DOING WELL IN SCHOOL, AND MAKING THINGS INSTEAD OF USING WHAT OTHERS MAKE. I MAKE WHAT OTHERS DON'T.

FAVORITE TOOL: DRILL, HACKSAW, OR JIGSAW (MY DAD WON'T LET ME USE THE CIRCULAR SAW OR TABLE SAW YET)

CURRENT PROJECTS: ONE-PERSON CANOE, RAIN-BARREL GARDEN IRRIGATION, R/C PREDATOR PLANE WITH CAMERA, AMMO-CAN CAMPING STOVE

James Conway





## Young Maker Profile: **JOEY HUDY**

In May 2011, when Joey Hudy went to his first Maker Faire in San Mateo, Calif., he didn't know what a significant impact it would have on his life. For the first time, he met lots of people who understood him, and this brilliant young maker realized his own brilliance. He attended three more Faires that year: Detroit, New York, and a Mini Maker Faire in his hometown of Phoenix, Ariz. On his website, Joey proclaims, "Going to Maker Faires has changed my life — it can change yours too."

And when Joey made his bike-pump-powered Extreme Marshmallow Cannon, little did he know he would be invited to the White House Science Fair in February 2012, and have the opportunity to fire it off with none other than President Obama, who called it "outstanding." Joey's next major project was his 3x3x3 LED Cube Arduino Shield, which he sells on his site, but in true maker spirit, he also shares his detailed build instructions.

Joey doesn't let the fact that he has Asperger's syndrome, a high-functioning form of autism, slow him down. He's a huge Arduino fan, and has taught himself programming languages and CAD software applications using online tutorials and a little help from friends he made at Maker Faire. Joey encourages other young makers to "dive right in" and pick up an Arduino, which he credits with teaching him so much of what he knows about electronics.

He's inspired by the work of Adafruit Industries, Mitch Altman, and MAKE, and wishes he had the opportunity to meek Nikola Tesla, who his dog is named after. Joey hopes to build a Tesla coil someday when he's saved up enough for parts. Making has helped him find his community, and fuels his personal motto: "Don't be bored ... MAKE something!"

—Goli Mohammadi

### **FUN FACTS**

AGE: 15

LOCATION: PHOENIX, ARIZ.

HEROES: DALE DOUGHERTY, MITCH ALTMAN,  
TYLER MOSKOWITE

FAVORITE ACCOMPLISHMENT: MEETING THE  
PRESIDENT, GETTING TO WHERE I AM TODAY, AND  
MAKING THE EXTREME MARSHMALLOW CANNON  
AND THE 3x3x3 LED CUBE ARDUINO SHIELD

FAVORITE TOOL: ARDUINO

CURRENT PROJECT: EL WIRE SHIELD

[lookwhatjoeysmaking.blogspot.com](http://lookwhatjoeysmaking.blogspot.com)





## Young Maker Profile:

# ANDREW KATZ

When Andrew Katz' brother snuck into his room and "scared the living daylights" out of him, instead of getting mad, he got smarter. Andrew combined ultrasonic sensors, an Arduino microcontroller, and his laptop to create his Notify Me Now stealth security notification system that alerts him whenever a sensor is tripped by changing images on his laptop screen. To test it for house-wide implementation, he prototyped it in a dollhouse, and shared his design with thousands of folks at Maker Faire New York 2011, when he was just 12.

Andrew was introduced to Arduino at his first Maker Faire in 2010, and knew he had to learn to program to use this amazing tool. Two introductory courses later, he was hooked on programming and Arduino, and a world of possibility opened up. Not surprising for someone who credits the science fair he attended in kindergarten as being the initial spark of inspiration on his road to being a maker. Andrew has also been influenced by *Smash Lab*, *MythBusters*, and building kits with his father and grandfather.

Clearly a practical problem-solver, Andrew's dream project involves systems to automate home environments of the elderly, inspired by a desire to help his great aunt Florence cope with her limited mobility. When asked about his dream job, Andrew replied, "An inventor and a scientist who also teaches people about making, which I will do a great deal of. I would also like to program because then I can make more complex devices."

If Andrew could use his ever-growing maker skill set to solve a world problem, he would focus on natural disaster detection and alert systems. Reading about his hero Bill Gates' work on devices to lessen or halt hurricanes and forest fires has sparked a deep interest in contributing to these solutions. His sage advice for other young makers? "I would tell young makers to always go for their ideas, to repurpose things, and to never give up."

—Goli Mohammadi

## FUN FACTS

AGE: 13

LOCATION: LARCHMONT, N.Y.

HERO: BILL GATES, BEN FRANKLIN, MYTHBUSTERS, SMASH LAB

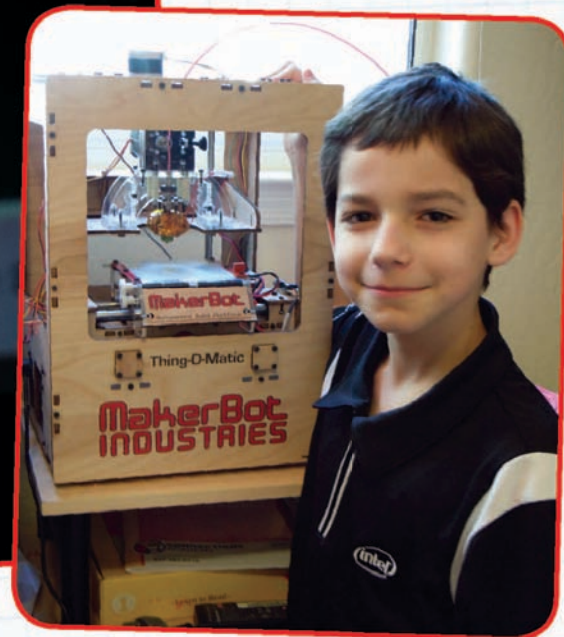
FAVORITE ACCOMPLISHMENT:

A BEDROOM SECURITY CAMERA SYSTEM USING VCRS, PHONES, CAMERAS, A DOORBELL, AND SWITCHES IMPLANTED IN KEYHOLES

FAVORITE TOOL: LEATHERMAN SQUIRT (MAKE: CIRCUIT BREAKER)

CURRENT PROJECT: AN AUTOMATIC DOG BALL SHOOTER WITH A PUSHBUTTON THAT TELLS THE ARDUINO WHEN TO PICK UP THE BALL AND LOAD IT INTO A FIRING MECHANISM





## Young Maker Profile:

# SCHUYLER ST. LEGER ↗

Schuyler St. Leger got his start with an original Lego Mindstorms RCX kit and was inspired by the tinkering of cartoon inventors Wallace and Gromit. From there he learned to write code with Processing and Scratch, explored electronics, and learned to knit from his grandma. The Garduino Garden Controller from MAKE Volume 18 opened his eyes to the world of microcontrollers.

"I had already built my own Intel Atom computer and played with Snap Circuits, but this exposure enabled me to take electronics to another level. I was hooked!" St. Leger recalls.

He has been a part of his local hackerspace, HeatSync Labs, for around four years. It was at HeatSync that he got his first taste of 3D printing. A fellow member brought in a MakerBot CupCake CNC, and St. Leger begged his parents for months until they got him one. When it arrived, he dedicated an entire week to putting it together.

"When you make something with your own hands not only do you yourself build it, but you also know how to fix it," he says. "You are your own customer support and repair technician! You get an intimate knowledge of your creation."

St. Leger even gave a talk at Ignite Phoenix in 2011, titled "Why I Love My 3D Printer," which has more than 300,000 views on YouTube. But he already has his sights set on MakerBot's new Replicator 3D printer, which has dual extruders for multicolored objects. (Though Schuyler dreams of modifying it to quadruple the print area and adding a third extruder.)

Schuyler's advice for other young makers is to just get out and experiment. "Explore as much as you can. Try to build things. If they work, great; if not, figure out why not."

He also recommends joining a local hackerspace or makerspace to learn from other makers. And when all else fails and something has you stumped: Google it!

—Craig Couden

## FUN FACTS

AGE: 12

LOCATION: PHOENIX, ARIZ.

HERO: BRE PETTIS (OF MAKERBOT INDUSTRIES)

FAVORITE ACCOMPLISHMENT: BUILDING MY 3D PRINTER AND SHARING MY PASSION FOR MAKING

FAVORITE TOOL: 3D PRINTER

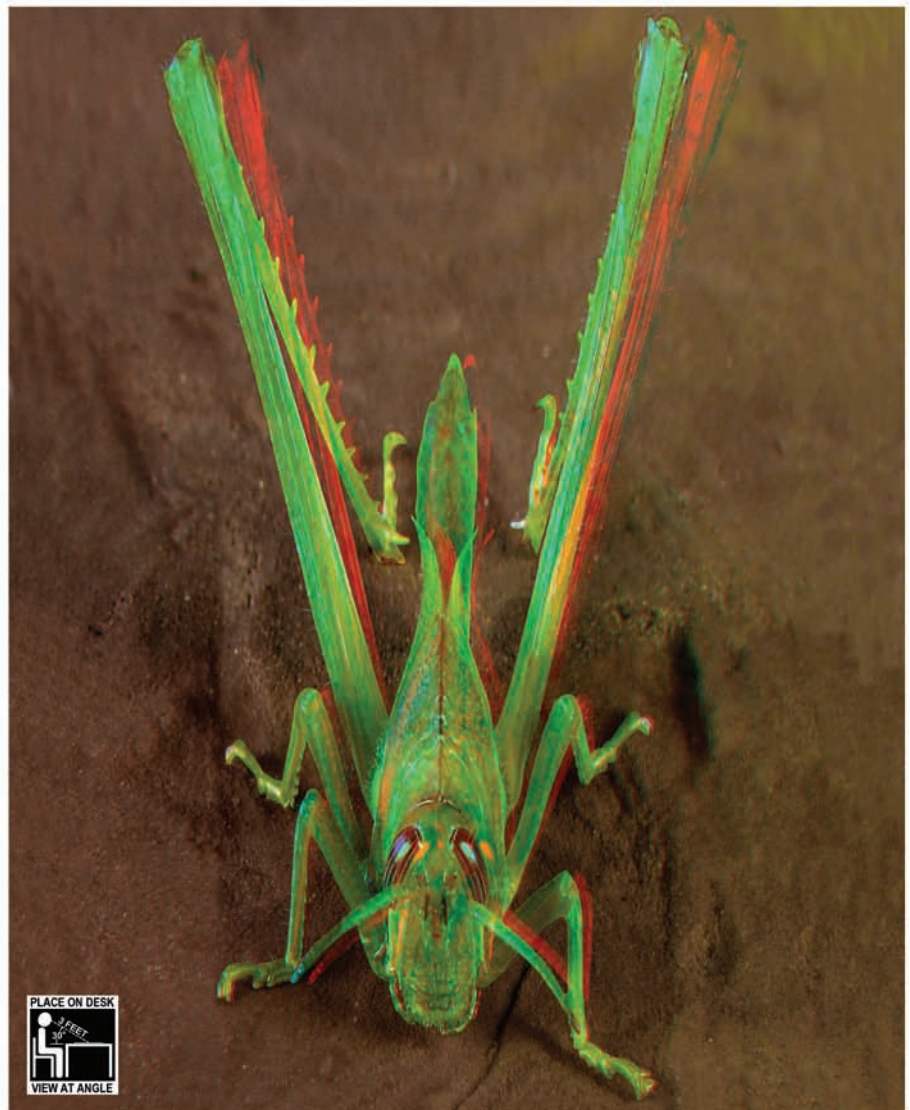
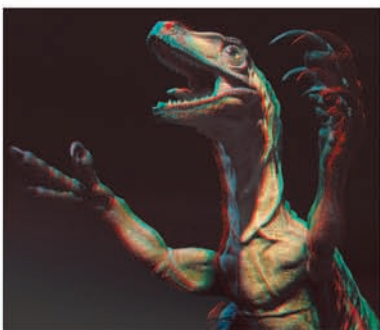
CURRENT PROJECT: TUNING AND CALIBRATING MY MAKERBOT THING-O-MATIC (MY SECOND 3D PRINTER) AND BUILDING A BETTER HOME PHONE CHARGER



As an increased number of 3D motion pictures are produced and 3D television begins to find its way into our homes, the brands that fail to adapt will quickly begin to look archaic next to their competitors. Much like the leap from black-and-white to color and from color to HD, this technological advancement will make even the most innovative ads of today look lifeless and dull by comparison.

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# LIFETIME CREATIVITY

A MASTER'S ADVICE FOR YOUNG MAKERS.

BY I-WEI HUANG



## THE BUILDING BLOCKS

Every kid draws; I just never stopped. I spent countless hours dreaming up and drawing robots and creatures. People often call the ability to do art a natural talent, something you're born with. But what many don't see are the obsessive hours spent trying to improve on a skill that can never be perfected. Art is both a need and a skill, and this duality fuels itself in an endless cycle.

As a kid, I also took a lot of things apart. I suspect most of you did and do too. Curiosity combined with the love of tinkering fuels both the destructive and creative side in us. I'm always eager and excited when something breaks around the house and I get a legitimate excuse to open it and see what's inside. I can't always fix the problem, but I always learn from the experience. Today, with the internet, it's even easier to find information about how to fix, make, hack, and destroy things.

Building on early visual interests, natural curiosity, and a love of making will fulfill you for the rest of your life. Today, I design video game characters and toys for a living, and it's the best job in the world.

## NATURE AND THE ILLUSION

People often ask me where I get the ideas for designing *Skylanders* char-

acters, as well as my steam-powered and little characterful robots. The answer is simple: nature! I have artist influences like everyone else, but the natural world, present and prehistoric, gigantic to microscopic, contains the best designs.

We are hardwired to know and feel when something resembles nature. So even when I make mechanical things, my aim is usually to create a bit of the illusion of life, based loosely on some natural design. I don't mean that you should copy nature directly, only that you should learn as much about animal anatomy and locomotion as possible. Each observation will become a tool in your toolbox, and with a mixed bag of tools, you can fool people into thinking that

you've created something that's out of this world — when in fact, it's the opposite.

## ROUGH IT OUT

The best single piece of advice I can give, for both drawing and physical hacking, is to test before you commit. If you draw a perfect eye, it's difficult to proceed because you then have to draw a perfect face around it. It's easier and more effective to rough out the big forms first, then make the final lines for your perfect eye once the foundation is good enough to continue.

The same is true for making mechanical things. I often mount components together temporarily before making the final mounting,



Tod Bice (photo): I-Wei Huang



Always stay curious; creation is a wonderful thing.  
All you need to do is pick your passion, develop  
it, and never stop building on your craft.



which can be a time-consuming process that involves irreversible drilling and cutting. I love zip ties and servo tape because they let you easily strap things together to test out part of a mechanism before committing fully to the design. I'm not an engineer, so I rely on trial-and-error — and it's better to do lots of little temporary trials in order to minimize the big, permanent errors.

### THE GOAL

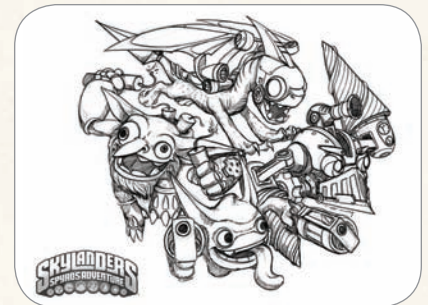
Always keep the big picture in mind. Don't lose your focus on the goal while you're working on the small details. It's always OK to change your goal during your process — that's the organic nature of art, and sometimes little mistakes turn out to be

great breakthroughs that change your goal. But always keep checking back to see if you're still progressing toward your last goal and confirm that it's still what you want.

### PICTURE IT

Visualize. Force yourself to not pick up your pencil or screwdriver for 20 minutes while you think about every aspect of what you're going to do. Visualize yourself doing it, in the correct sequence, like you're actually doing it. This is a difficult thing to do, but gets easier with practice.

By visualizing in your head, you're actually problem solving, working out the big, obvious problems. By the time you get to the actual doing, you're only facing smaller detail



problems. Your brain makes mysterious connections when you force it to only practice and not yet act. Once you've mastered how to do this in your head, you'll never be bored.

### BE DONE

Lastly, know when to consider a successful project finished or an unsuccessful project bad enough to stop. The obsessive nature of creation can often lead to much time and energy wasted on a project. Knowing when to stop is difficult, but it's easier if you just put the project aside and let your brain rest. I often come back to old projects weeks, months, or years later, with a fresh perspective.

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I-Wei Huang is an artist and animator for the video game industry. He's best known for his tinkering in working steam-powered machines and other characterful robots, under the name CrabFu ([crabfu.com](http://crabfu.com)).



# MORE MAKING MAKERS

PROJECT MAKE BRINGS HANDS-ON LEARNING  
TO HIGH SCHOOL STUDENTS. BY CASEY SHEA



When I was in school, along with my regular academic classes, I had the opportunity to take practical arts classes in drafting, cooking, and sewing, as well as shop classes working with wood, metal, and autos. These experiences, in addition to summers tagging along with my jack-of-all-trades grandfather, helped to instill in me not just an enthusiasm, but a need to fix, create, and make things.

After a decade of teaching high school math, when presented with the opportunity to teach a new class that promised to let kids just make things, naturally I jumped.

Over the summer, a dedicated handful of students and I moved tools and equipment from an abandoned lab on the campus of Analy High School in Sebastopol, Calif., to a mostly vacant space down the hall from the headquarters of MAKE magazine. We built the tables and storage units, rummaged through surplus electronic components, and prepared to sail into the uncharted waters of Project Make.

The initial class consisted of 29 students ranging from sophomores to seniors, from AP students to those struggling in basic classes. The blend of grade levels and academic abilities provided a unique mix from which I believe all the students benefited.

Through the class, students have learned some basic construction tools and techniques, explored electronics by putting together simple and complex circuits, and dabbled in design, computer programming, and blogging. For several students, Project Make provided a first opportunity to use a power drill or pick up a soldering iron. Knowing that several people learned a new skill or understand a little bit more about how things work — how threads are cut into galvanized pipe, for instance — has been a very gratifying experience for me, regardless of whether or not they ever use the skill again.

As any maker knows, frustration and failure are most often a part of the process. Rarely does something work exactly as expected the first time; iterative adaptability is a requirement for success. One of my goals at the outset was for the students to develop tenacity and willingness to learn from challenges, to redefine and even embrace failure as a necessary part of the learning process. Results have been mixed but far more successful than in my regular classes. These lessons are hard to teach in a traditional classroom setting where success is measured through more standard means.

Besides sharing the joy and challenges of making, another goal of mine has been to develop and exper-

iment with projects and activities that I could bring into my traditional math classes to help students grasp abstract concepts. Time and energy constraints have conspired to limit the achievement of this goal, but my idea notebook is full of sketches and possibilities that I intend to pursue over the summer for inclusion in Project Make version 2.0 next year.

From the start, the response from the community has been extremely enthusiastic. Parents have donated supplies and hackable gear, requests for visitations from school and community members have been numerous, and the reactions overwhelmingly positive.

A universal feeling that we are short-changing students by limiting options for engaging in their work and using their hands has sparked a dialogue of what a 21st-century shop class should look like. I would love to expand that dialogue to include anyone with experience or interest in making and education. A forum for this dialogue is available at [makezine.com/go/makerspace](http://makezine.com/go/makerspace). Please join in if you're interested in helping make more makers.

---

Casey Shea is a Sonoma County native who's been teaching math at Analy High School since 2001. Having spent most summers growing up working alongside his handyman grandfather, he strives to show the intersection of math and making through his teaching style.

Gregory Hayes







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Virginia Tech engineering student Derek Lahr made his senior design project on his graduation present, a Tormach PCNC mill.

"One of my research projects at Virginia Tech was to make a continuously variable transmission (CVT) for a bicycle. To get continuously variable ratios out of the transmission, one of the parts in the cam changes shape along its length. I needed a 4th-axis CNC with a rotary table to get it done. While I was researching ways to solve the problem on the bicycle design, I discovered the Tormach mill and saw that it had 4th-axis capabilities, was economically priced, and the right size."

Back in the laboratory, Lahr transferred the skills he honed while completing the bicycle project to several robotics projects in the works at RoMeLa—and he took his PCNC mill with him.



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# TIPS FOR BUILDING WITH KIDS

EDUCATORS SHARE THEIR TOP FIVE POINTERS FOR A HAPPY BUILD.

More and more parents are taking it upon themselves to organize groups of kids for after-school hands-on learning projects. Read Joe Mayer's account of building robots with 7- to 10-year-olds at [makezine.com/go/educate](http://makezine.com/go/educate) for inspiration. To gather pearls of wisdom, we asked a few of our favorite educators, "What are your top five tips for building projects with a group of kids?"

## GEVER TULLEY

Founder of Tinkering School and Brightworks School, author of *50 Dangerous Things* ([gevertulley.com](http://gevertulley.com))

### 1. Don't be a backseat driver.

It's OK to drive the project when it really needs help, but let them drive as much as possible, even if they're going in the wrong direction. Mistakes often lead to deeper understanding, and blind alleys sometimes lead to new possibilities.

### 2. Make a plan at the start of the project that gives chunks of work to smaller groups of kids.

If you're building a go-kart, then two kids are working on the chassis and two kids are working on the steering, until all the participants have jobs. Let each sub-team make their own implementation decisions and act on them.

### 3. Use real tools and real materials.

There are very few tools that children can't learn to use safely and well — except "kid-friendly tools."

### 4. Build big.

The bigger, the better. If you're building a treehouse, make it two stories; if you're building a boat, build one big enough for the whole team. There's nothing so memorable as being a part of building something bigger than yourself.

### 5. Prevent catastrophic error, but allow small mistakes to happen naturally.

Nobody needs to break a bone just to learn to pay more attention, but a bruise or scrape can be an excellent teacher.

## RICK SCHERTLE

Middle school teacher, MAKE author, after-school project build organizer

**1. Safety first.** Glue guns are hot and eyes fragile, but don't be so cautious you take the fun out of making. See Gever Tulley's book *50 Dangerous Things* for more on this.

**2. Don't edit kids' work.** Let them create without adult intervention.



### 3. Practice what you teach.

Be working on projects yourself!

### 4. Mostly lab, minimal lecture.

Kids always learn and remember more when they're experiencing and doing.

**5. Plan ahead to keep things moving.** As a teacher with 35 students in my class, I'm always thinking of flow and logistics to manage things sanely.

## MICHAEL SHILOH AND JUDY CASTRO

Engineer and artist, both educators who lead electronics/mechanics workshops for kids ([teachmetomake.com](http://teachmetomake.com))

**1. Make it easy for children to feel they can do as well as, or even better than, you.** If you do something that looks too perfect, it can be intimidating. Build prototypes that make the viewer think, "Oh, I could build that."





Safety glasses must be worn by all!

**5. Be flexible, adaptable, and always patient.** Breaks are essential, so make them part of your planning. Learning can and should be great fun. Be fearless in the pursuit of knowledge, and the kids will be too.

### CAROL SMITH

*Educator specializing in working with kids who need extra help or alternative learning environments*

**1. Teach kids that only they have the right and responsibility to clean up what they've created.** No one will come along and "tidy up" something they were still working on, so they need not worry that their creations will be destroyed. By the same token, no one will come along and do their cleanup, so they should be considerate of others and clean up messes.

**2. Always bring LEDs, whether the project needs them or not.** Everyone loves LEDs, and they can be added to almost anything.

**3. Use familiar objects.** They're a lot less intimidating. Clothespins, chopsticks, popsicle sticks, and wine corks are some of our favorite construction materials.

**4. Encourage children to add their own items to the projects, either as functional or decorative parts.** These can be toys they no longer use or parts of broken toys, scraps from other projects, pictures, etc. This creates a sense of personalization and ownership.

**5. Have things on hand to take apart.** Often when kids are stuck in a project, we have them spend some time taking stuff apart. This is inspirational, educational, and provides components for use in their projects. It's also environmentally friendly and teaches responsible resource utilization. Teach safety as needed, but don't overwhelm with long lectures.

### JOE MAYER

*Educator, parent, after-school project build organizer*

**1. Start by asking each kid, in turn, what his or her interests are.** By knowing those interests and some experiences they tell you of, you can often relate a new skill they're trying to learn with one they already feel confident about.

**2. Be ready to break a task into smaller steps by thinking through the task ahead of time.** Some kids may have trouble with multiple-step procedures, and this allows everyone in the group to feel good. Kids who finish a task sooner can be enlisted to help others.

**3. Remember, you can take the time you need, and it's more fun that way.** Building stuff is not like in school, where you have to finish up in that class period. This advice is from my 9-year-old son, Nicko.

**4. Be mindful of setting a serious and, most importantly, a consistent example with regard to safety.**

**2. Encourage them to be brave and do hard things.** Embrace challenge instead of fear it. If it isn't at least a little hard it probably isn't as valuable as a learning piece. Keep ideas in "the flow": not too hard, not too easy, just right.

**3. As an educator, embrace your own ignorance and delight in the wonder of exploration.** Let kids see you make mistakes and learn that these mistakes lead to new understandings. Find ways to ask questions that motivate your learners to ask their own questions and to then seek out the answers.

**4. Establish, keep, and honor relationships first.** Everyone learns best from folks they feel the most comfortable around.

**5. Above all, do no harm.** The old saying that it's all fun until someone loses an eye really is true! It's very important that the kids know this. Consistency is key.



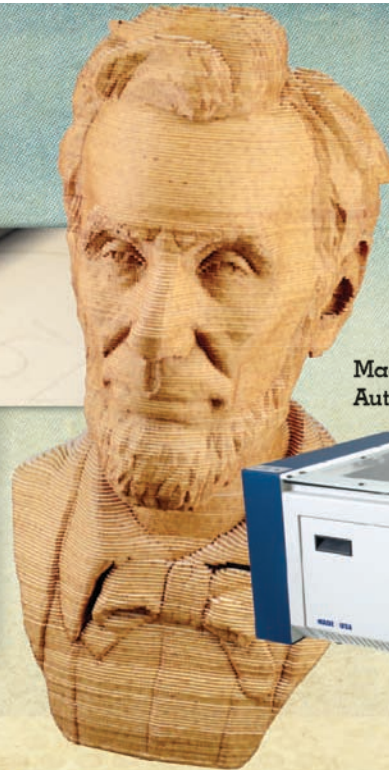
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Fig 1. Telekinetic technology.

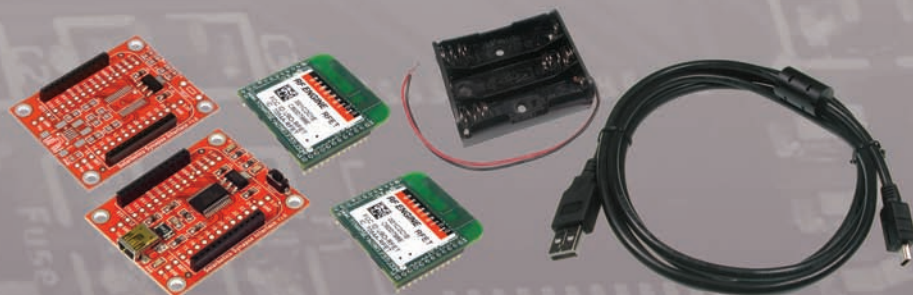


Fig 2. Awesome wireless technology. Note the total lack of weird/creepy.

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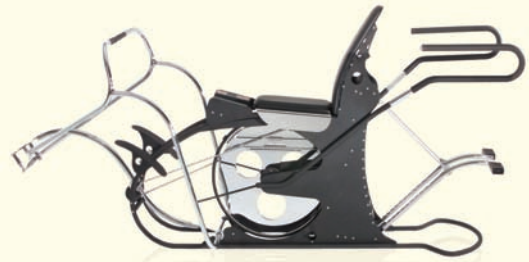
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# TOOLS AND TOYS

FOR KIDS BY KIDS



You talkin' tuh me?



## DOODLER 3D

Free [doodler3d.trevorboyle.com](http://doodler3d.trevorboyle.com)

I like how you could use the draw sliders to make the lines pop out more. The Undo button was convenient (some doodle games don't have that and you wish they did).

It was really entertaining. I made a picture with mountains and a house — you could see that the mountains were behind and the house in front.

There were some random places in the frame where the program wouldn't allow me to draw, and that was weird. It meant I couldn't add the detail I wanted. It would also be nice if you could choose different background colors.

I'd like to spend more time with the program so I can get more control over my doodles.

—Nina Cauntay, age 10

## DUCK TAPE

\$5 [duckbrand.com](http://duckbrand.com)

Duck tape rocks because there are so many different designs and colors and things you can make with it. Right now, my favorite things to make are wallets — I like to come up with new styles and color combinations. The only thing that bothers me is that you can't use scissors to cut it, but an X-Acto knife works (they're just really sharp!). All my friends love to see my new Duck tape creations, and they make really great gifts.

—Ella Morgan, age 9

## RED TOOLBOX TOOLKIT 10-PIECE SET

\$20 [red-toolbox.com](http://red-toolbox.com)

This toolkit has everything you need, even safety goggles. The grip on all of the tools really makes them safer and more secure in your hand. My favorite tool is the saw because it actually works! The only thing that would make this toolkit even better is if the tool belt had pockets for specific tools. Right now my hammer is banging around in the big front pocket, but I'm going to sew on a little hammer loop to fix it, so it's no big deal.

—EM





# DREMEL 300 ROTARY TOOL

\$58 [dremel.com](http://dremel.com)

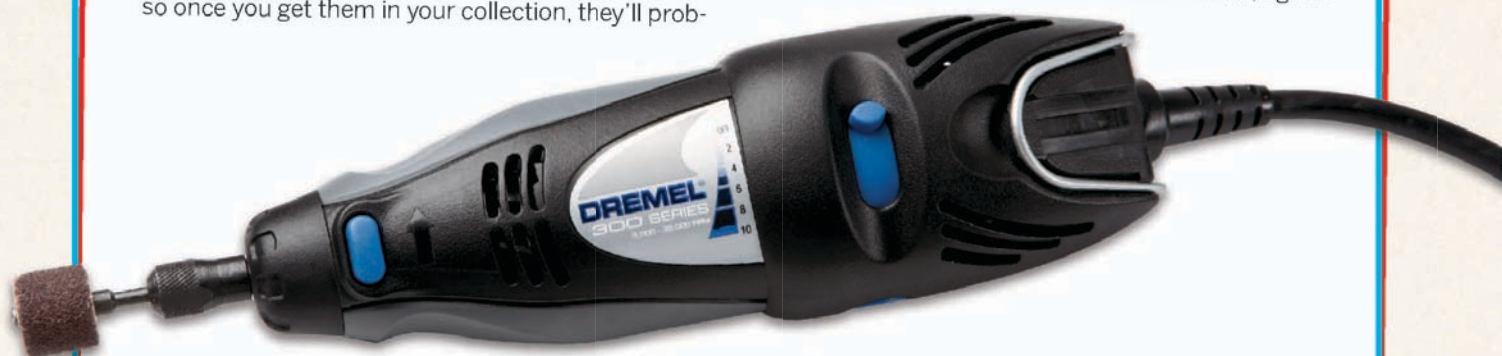
I love the Dremel. You can use it for almost anything, from sharpening scissors to shining up old tools. I used the Dremel to take rust off of an old metal lawn chair, and it worked really well. It fits in my hand nicely, and unless I use it for a long, long time my hand doesn't get tired from holding it. I usually hold the Dremel like a pencil, and that works best for me.

I love all the little accessories that you can get with it. There are engravers, bristle brushes, sanding drums, and more. This is maybe one of the bad things with the Dremel: the accessories can get expensive. But they don't seem to wear out too fast, so once you get them in your collection, they'll prob-

ably be OK for a while. Another con (for an 11-year-old) could be attaching the accessories. It's hard to hold the lock button down, hold the accessory in place in the collet, and tighten the collet nut. I can do it, but it gets a little tricky.

I like the different speeds on the Dremel. Sometimes you need a little direction on what speed to use, but you can check in the Quick Start Book and it will give you a clue. I love the Dremel because it's so handy — it seems like a whole bunch of tools but it's just one. My Dremel also came with a nice case, to keep it clean and safe.

—Sara Hodek, age 11



**KREG  
JIG**

\$100 [kregtool.com](http://kregtool.com)

The Kreg Jig is so simple and easy, I first used it when I was 12. The pros are that it cuts the same hole angle each time, is easy to use, makes drilling holes a lot faster, and has the bench-top and portable base. The only con is that you have to use Kreg jig screws. I like using the Kreg Jig because it works fast and anyone could use it. It's a great tool for hidden joints and can be used on different dimensions of lumber.

—Tim Hodek, age 15

## MAKE: CIRCUIT BREAKER LEATHERMAN

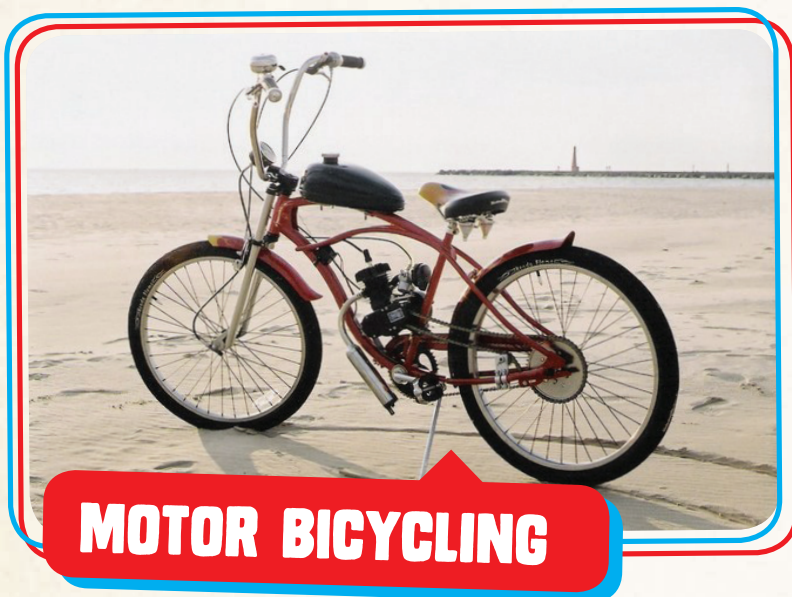
\$36 [makershed.com](http://makershed.com)

The Make: Circuit Breaker is my favorite tool because it has all of the tools that any maker should have nearby. It has a small knife, two different screwdrivers, a wire stripper, a wire cutter, and a ruler. This makes it ideal for building and breaking any type of circuit!

—Andrew Katz, age 13







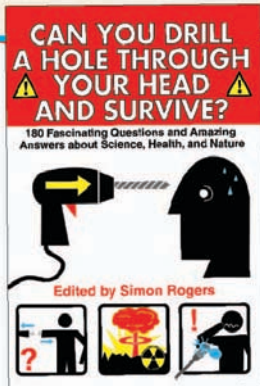
## MOTOR BICYCLING

[motorbicycling.com](http://motorbicycling.com)

All you DIYers who have old bikes lying around: motor bicycling is the perfect project for you. It involves taking motors from chainsaws, weed whackers, and such, and putting them on bikes. It's very energy efficient — up to 100mpg, plus it saves an old bike from a landfill — and it's just plain fun.

[Motorbicycling.com](http://Motorbicycling.com) is a friendly forum where all newbies are welcomed with open arms. You can get expert advice and safety tips, and follow other people's projects, or you can make your own thread, post pictures, and write reviews of your own motorized bike. And when I say expert advice, I mean it. Members with a lot of experience share with you to keep frustration at a minimum on your bike build or kit. Whether you use the friction, direct, or pusher methods (to learn what these are, check out the site), this is the ultimate resource for DIY motor bikers.

—Sam Fraley, age 13



## DRILL INTO YOUR HEAD

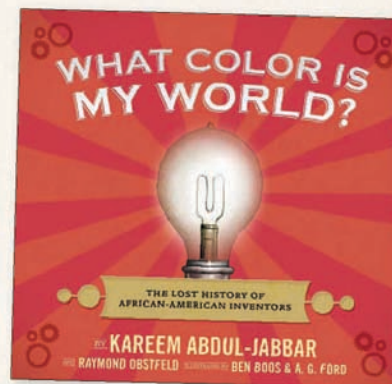
*Can You Drill a Hole Through Your Head and Survive?* by Simon Rogers \$13 Skyhorse Publishing

Here's a fun, interactive book that features 180 fascinating questions and answers about a wide range of topics, including Science and Technology, Sports and Games, and Health and Fitness. Each answer is backed up by a paragraph or two giving a thorough explanation using scientific research.

You'll be surprised by what you'll find out from this book, including my favorite questions: *Could we actually build a Star Trek phaser gun?*, *Is suspended animation safe?*, and *Are cloned animals safe to eat?*

Whether you're looking for a short, entertaining read that will open your eyes to some of the scientific research being done around the world, or just a book to put on your coffee table, *Can You Drill a Hole Through Your Head and Survive?* is a good choice.

—Kindy Connally-Stewart, age 16



## SHEDDING LIGHT

*What Color Is My World: The Lost History of African American Inventors* by Kareem Abdul-Jabbar \$18 Candlewick Press

I especially liked reading about George Crum, inventor of the potato chip, and Alfred Cralle, inventor of the ice cream scoop. To me, the Super Soaker is the best creation, and I was happy to know the inventor, Lonnie Johnson, is African American. I wish I would see more of these inventors in my history books at school. Like the book says, "There's more to our history than slavery, jazz, sports, and civil rights marches."

—Hannah Rogers, age 9

**Nina Cauntay** loves making art, playing cello, hip-hop, and spending time with her friends and family.

**Kindy Connally-Stewart** is a 16-year-old sports and science junkie who cut his teeth on Lego and Harry Potter.

**Sam Fraley** lives in St. Louis, Mo., and is an avid garage hacker.

**Sara Hodek** loves entomology, reading mysteries, and curling.

**Tim Hodek** is an avid curler and golfer and likes the outdoors.

**Andrew Katz** lives in New York and loves Arduino and programming.

**Dylan Kirdahy** is a robotics enthusiast.

**Ella Morgan** loves animals, writing stories, playing piano, and making Duck tape everything.

**Hannah Rogers** loves to read, play games, and ask lots of questions.

**Robert M. Zigmund** loves his subscription to MAKE.



# AR.DRONE

\$300 [ardrone.parrot.com](http://ardrone.parrot.com)

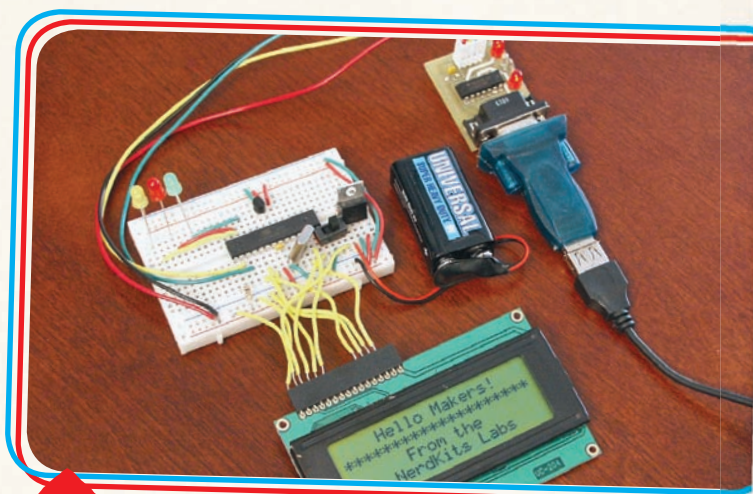
Parrot incorporated some amazing technology into the AR.Drone. The quadcopter (which has four propellers as opposed to one) is easy to navigate thanks to two cameras — one facing forward, the other facing down. The drone is able to tell when it flips over by sending out ultrasound waves that “see” the ground.

One of the most remarkable things about this device is that it can be controlled by an iPod touch, iPhone, or iPad — although I advise you to master it indoors before you take it outside and remove the indoor hub with its propeller protectors.

—Robert M. Zigmund, age 14



**GET  
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## NERDKITS

\$80 [nerdkits.com](http://nerdkits.com)

Ever since I got into robotics, I've wanted to know more about electronics and programming. I wanted a good kit with a microcontroller, but the kits I found were either too advanced or too dumbed-down without many interesting components.

I finally found a good kit. A USB NerdKit comes with a lot of great stuff, including an ATmega168 MCU, a buzzer, a 420-character LCD display, three different colors of LEDs, a temperature sensor, switches, and a potentiometer. It even comes with a great guide and programmer! The guide starts at the basics and works its way up to more advanced topics. The programmer comes with multiple languages and sample codes.

The NerdKits support team is quick and helpful. There's a great forum and even video tutorials that explain how the programs and circuits work. I would definitely recommend a NerdKit!

—Dylan Kirdahy, age 14



## DESKTOP TREBUCHET MODEL KIT

\$50 [rlt.com/10421](http://rlt.com/10421)

RLT Industries has gone above and beyond with this kit. Each piece of wood is precisely laser cut. All the required tools can be found around your home or at a hobby shop, and the instructions are well-documented and detailed. However, as instructed, I used wood glue but it didn't hold well. So I resorted to a hot glue gun.

The overall building process 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.

—RMZ



# Summer Games

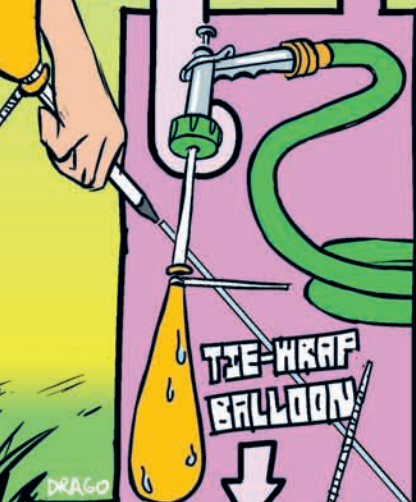
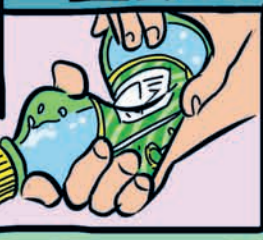
"GAMES LUBRICATE THE BODY AND THE MIND."  
- BEN FRANKLIN



BALLOONS



PLASTIC BOTTLES



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