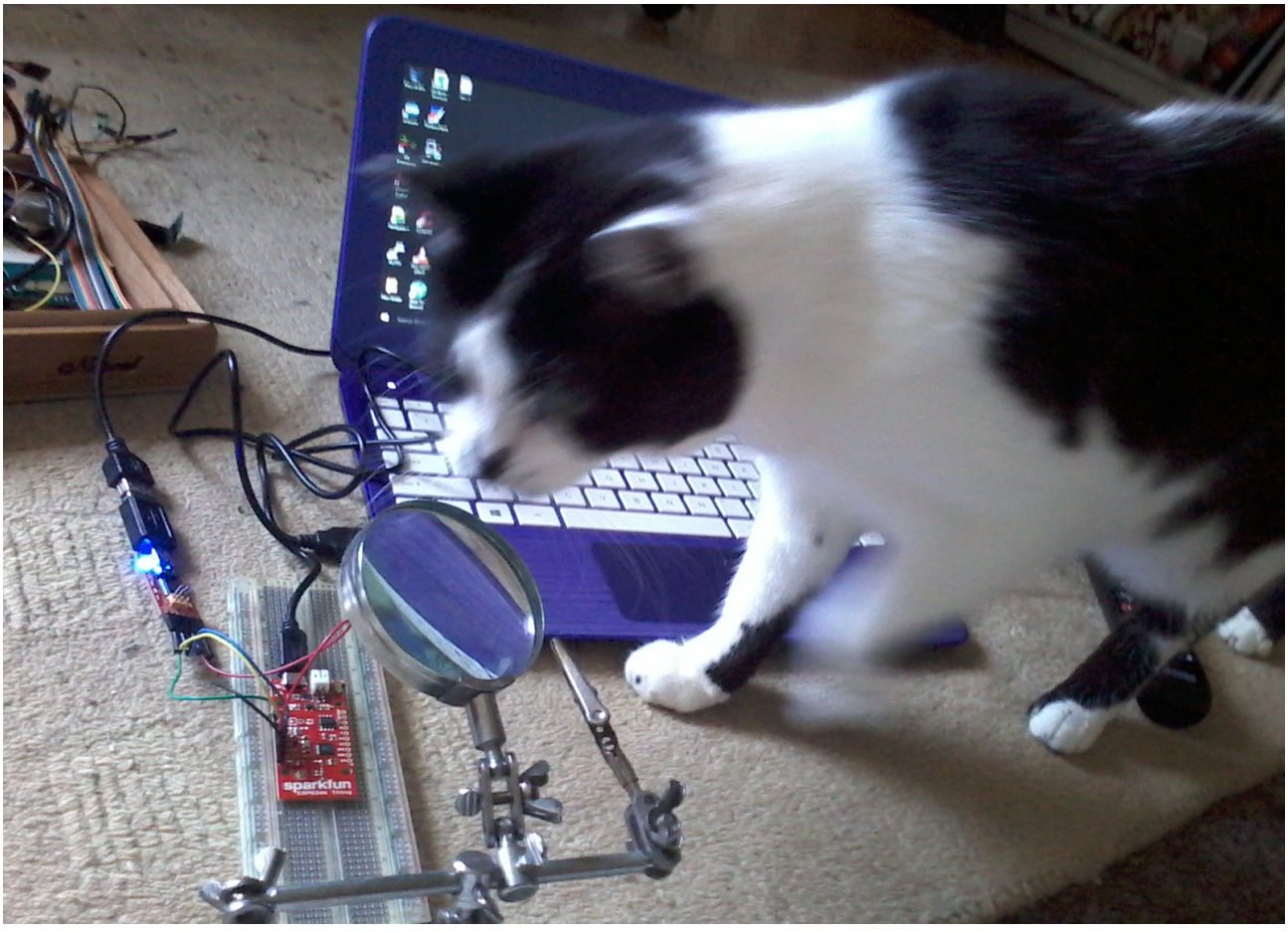
From the pages of **Make:**

Cat Projects



DIY Projects to Serve Your Feline Overlords

From the pages of Make:

Cat Projects

DIY Projects to Serve Your

Feline Overlords

From the Pages of Make: Cat Projects
DIY Projects to Serve Your Feline Overlords

Published by Maker Media, Inc., 1700 Montgomery Street, San Francisco, California 94111.

Maker Media books may be purchased for educational, business, or sales promotional use. Online editions are also available for most titles (safaribooksonline.com). For more information, contact our corporate/institutional sales department: 800-998-9938 or corporate@oreilly.com.

Publisher: Roger Stewart
Editor: The Editors of Make: Magazine

July 2018: First Edition

Revision History for the First Edition

2018-07-18 First Release

See oreilly.com/catalog/errata.csp?isbn=9781680455328ISBN13 for release details.

978-1-680-45532-8

How to Contact Us

Please address comments and questions concerning this book to the publisher:

Maker Media, Inc.
1700 Montgomery Street
San Francisco, CA 94111

Maker Media unites, inspires, informs, and entertains a growing community of resourceful people who undertake amazing projects in their backyards, basements, and garages. Maker Media celebrates your right to tweak, hack, and bend any Technology to your will. The Maker Media audience continues to be a growing culture and community that believes in bettering ourselves, our environment, our educational system—our entire world. This is much more than an audience, it's a worldwide movement that Maker Media is leading. We call it the Maker Movement.

For more information about Maker Media, visit us online:

- Make: and Makezine.com: makezine.com
- Maker Faire: makerfaire.com
- Maker Share: makershare.com

To comment or ask technical questions about this book, send email to books@makermedia.com

From the Pages of Make: Cat Projects

Table of Contents

MAKING A CAGE TRAP

Catch pesky animals humanely with a homemade slammer. By William Gurstelle

Consider the natural relationship between making things and urban homesteading. Even the smallest garden requires a bit of technology to be successful. Seedlings must be watered, weeds pulled, and garden pests kept at bay. All these tasks require paraphernalia of some kind.

Our modest-sized garden is in a residential neighborhood in Minneapolis. Despite the urban locale, there are hundreds of wild animals in the area. I've observed raccoons, squirrels, rabbits, voles, chipmunks, and, once, an opossum. By far the most plentiful wild mammals are the rabbits. Any evening, summer or winter, a walk up and down a single block all but guarantees a half-dozen rabbit sightings. Typically they're sitting quietly on front lawns, eating. These rabbits eat a lot: grass and clover certainly, but also perennial plants, young trees, annual fl owers, and most irksome to gardeners like me, vegetables. There are so many rabbits and they are so hungry that every garden must be well fenced.

Luckily, fencing is cheap and effective; so far no adult rabbit has breached the integrity of our garden's chicken-wire fence, and our harvest hasn't materially suffered from the leporine onslaught.

But not all is rosy in the urban homestead. Outside the fence, rabbits continued to feast on ornamental plants and shrubs. And smaller creatures slipped through the chicken wire: chipmunks took the tomatoes and battered the basil without remorse. For several days in a row, as our tomatoes neared ripeness, my wife and I entered the garden with happy anticipation only to discover an animal pest had beaten us to the fruit.

As a maker, I decided to make something to take care of the problem.

Photograph by William Gurstelle

MATERIALS

Pine board, 1×6, about 48" long A nominal 1×6 board is really ¾" thick by 5½" wide. You'll cut it into many smaller boards (see Step 1).
Screw eye, medium
Screw eyes, small (2)
Music wire, .056" OD, 14" length
Tee hinges, 2", with mounting screws
Hardware cloth, ¼" mesh: 36"×24" (1), 8"×8" (1)
Thin wood or cardboard, 2"×6" strip for the trigger plate
String, 3'
Nails, 4D, 1½" long (1 box)

TOOLS

Table saw or buy wood pre-cut to size
Hammer
Wood glue
Screwdriver
Needlenose pliers (2)
Wire cutters
Staple gun
File

Removing small nuisance animals can be accomplished in a variety of ways. The most straightforward is the simple noose snare. It's merely a loop of picture-hanging wire placed over a known animal runway and secured to a stake in the ground. The animal enters the loop headfirst and becomes ensnared when the loop pulls tight.

I didn't have great luck with the snare. The rabbits, perhaps sensing danger with native bunny intuition, would hop around it or over it. The one time I caught a rabbit, the animal was able to back off and loose itself from the trap. After a while, the animals avoided the snared runway altogether.

I considered building a deadfall trap, the staple of many a Roadrunner cartoon. When the animal takes the bait, a trigger lever causes a weight to fall and crush the unsuspecting prey. Such a trap can be made to any size; indeed, Wile E. Coyote often used a large safe for the deadfall. But in reality, a deadfall trap is easier to envision than to make.

An adult rabbit is pretty large, so the deadfall needed to crush Thumper has to be big. Devising a trigger that could support a rabbit-crushing rock, yet reliably trip when the rabbit was in position, was a difficult proposition. Plus, I didn't want to accidentally hurt my dog, or have to dispose of a mangled but still breathing animal. So I set aside the deadfall idea.

The Cage Trap

The cage trap is the king of animal traps: reliable, humane, and fun to build. I've enjoyed great success with these devices. A cage trap consists of a wire mesh box with one hinged door. The door is held open by a movable latch, which retracts, shutting the door, when an animal steps on a trigger plate located deep inside the box. The garden pest is held securely and humanely inside the box until the trapper disposes of the animal.

I built this trap in a few hours for about $5 in material costs. Once built, it trapped its first chipmunk in less than half an hour. Chipmunks and rabbits, not being especially bright animals, are quite easy to trap with the appropriate bait.

1. Cut the boards.

From your 1×6 board (which is really ¾"×5½"), first cut an 8" length. This is the trap's door.

Cut a 24" length and from it, rip 4 strips each ¾"×24" and one ¾"×22½" (long frames). From the remaining 24" scrap, cut 2 strips ¾"×8" for the trigger support board and small screw eye support board.

From the remaining board, cut 8 strips ¾"×7" (end frames), and 2 boards 1½"×7" for the medium screw eye support board and hinge support board.

2. Build the frame.

Build the cage trap frame from the 5 long frame and 8 end frame pieces as shown in the assembly diagram (Figure A, following page), using nails and glue. This size of trap works well for squirrels, rabbits, and chipmunks; you can scale it up for use with larger animals.

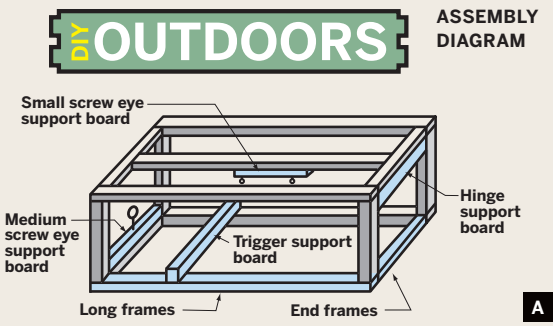
3. Attach the support boards.

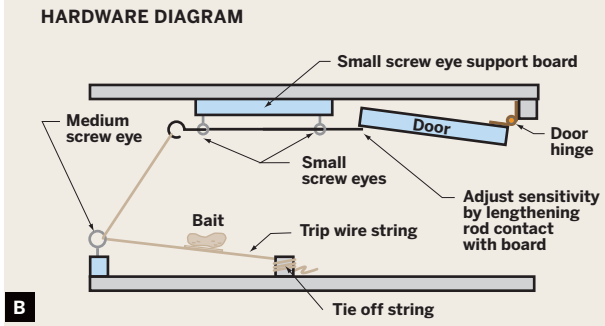
Following the assembly diagram, attach the trigger support board, hinge support board, medium screw eye support board, and small screw eye support board. The small-eye board must be set back far enough to clear the cage door when it's fully opened.

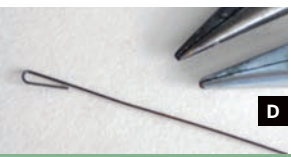
4. Attach the hardware.

Screw in the hinges and screw eyes as shown in the hardware diagram (Figure B).

DIY OUTDOORS







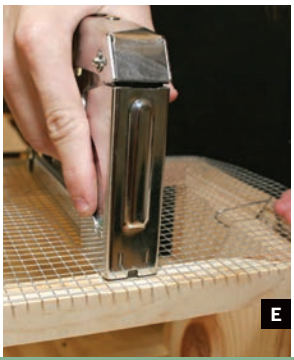


Fig. A: Frame assembly diagram. Fig. B: Hardware diagram. The latch releases the trap door when the animal takes the bait and trips the trigger string. Fig. C: To make the door lock, bend a 6" length of music wire. Fig. D: The latch is just a length of music wire with a loop in one end. Fig. E: Staple the hardware cloth to the cage frame. Fig. F: Run the string from the latch through the medium screw eye, then tie it off.

5. Make the door lock.

Cut a 6" length of music wire and use 2 pairs of needlenose pliers to bend it into the door lock, as shown in Figure C. Attach the lock to the door with the staple gun.

6. Attach the door.

Attach the door to the hinges. Test the door to make certain it closes easily and the door lock operates correctly. Adjust as necessary.

7. Bend a loop in the latch.

Cut an 8" length of music wire and use the 2 pliers to bend one end into a tight loop (Figure D).

8. Attach hardware cloth.

Attach the large piece of hardware cloth to the trap frame using the staple gun (Figure E). Bend the hardware cloth so it fits tightly against the frame, cut off any excess, and file the cut ends smooth.

Attach the small piece of hardware cloth to the open end using the staple gun.

9. String the latch and trigger.

Tie the string to the loop on the music wire latch. Insert the latch through the small screw eyes until ¼" of the latch end supports the door. Run the string through the medium screw eye and tie it off on the trigger support board (Figures B and F), following the hardware diagram.

10. Set the trap.

Choose the location of the trap carefully, away from people and pets, but in the area where the pest animals have been most active. Conceal the trap by placing it under vegetation.

Place your trigger plate over the string and bait the trap by placing the animal's favorite food on the plate. When the animal enters the cage and takes the food, it will cause the latch to release and the door to shut.

Chipmunks and squirrels seem to love peanuts. Rabbits are fond of Romaine lettuce. Carnivorous animals are attracted by raw liver.

Once the animal is trapped, you have various options for disposing of it, ranging from releasing it at an appropriate location to preparing a delicious rabbit fricassee. Irrespective of your disposal method, use caution to avoid being bitten or unnecessarily stressing the animal.

William Gurstelle is a contributing editor of MAKE.

Photography by Ed Troxell (C, E), William Gurstelle (D), Sam Murphy (F)

DIY

HOME

THE CIVILIZED CAT

Train your feline companion to use the toilet. By Josh Klein

Would you let your guests crap in a box on your floor? No? Then why would you let your cats? Here's how to get them using the toilet like civilized members of the family.

Aside from the risks of toxoplasmosis and other diseases transmitted by cat feces, there's significant labor for the owner involved in maintaining a litter box. Being inherently lazy, I decided it would be easier to just toilet-train the cat. There are commercial solutions available (CitiKitty is a good one), but I found it's easy to make an equivalent device from a few items at the dollar store.

One big advantage to doing it yourself is that you can cater the process to your cat's learning curve, which can vary widely from animal to animal.

Functional Overview

The system is a toilet lid with a fl at-bottomed bowl attached to its underside. It starts out just like a regular cat box, except nestled in your toilet. Over time you can cut away more and more of the bowl (where your cat will be standing), thus forcing the cat to adapt to standing on the lid and squatting over the hole that contained the bowl. During the training process a dustpan or another bowl can be used to catch the litter when you need to use the toilet.

In designing this system I tried to make it as easy for the cat to use it as possible. One issue many cats have is that squatting on the toilet seat (not the lid) is a slippery, sloped, and narrow proposition. If your cat is at all standoffish about this (mine sure was), then this system ought to work better. As an added advantage, this system allows you to put the lid down so you don't sit on whatever your cat has tracked in on their paws. The components should cost you roughly $10.

Photography by Hulda Emilsdottir

Fig. A: Mark a plastic bowl for cutting into a litter holder. Fig. B: Fit the bowl against the back of the toilet seat lid. Fig. C: Mark bowl position on the lid. Fig. D: Cut a circle into the lid over the bowl location, small enough to let the cat squat in front. Fig. E: Litter holder bowl screwed securely onto toilet seat lid. Fig. F: Sand the front of the lid so it takes glue better. Gluing sandpaper back-side down turns this into a sure-grip platform for your cat.

MATERIALS AND TOOLS

Toilet seat with lid about $3. Cheap lids may be better as they're likely to be thinner plastic, and hence easier to cut.
Flat-bottomed plastic bowl that can be cut without cracking. Get one with as short a slope as possible around its edges — the cat will stand in the bottom. The bowl must be big enough to fit inside the toilet seat and have a lip that extends past the hole in the seat, so that it suspends inside the seat. Get as close a fit as possible — the bigger the bowl, the happier the cat.
Machine screws and nuts (3)
Large-grit sandpaper
Household glue
Sharpie
Dremel rotary tool
Flushable cat litter World's Best works well.
Cat

Construction

This project is easy; overall it took me about an hour to set up.

1. Cut off one edge of the bowl in a straight line across the point where the lip meets the flat bottom (Figure A). Use a Dremel to smooth the sharp edges.

2. Put the bowl into the toilet seat and close the lid. Flip the toilet seat/lid upside down (Figure B) and lift the seat off. Mark where the bowl sits on the lid using a Sharpie (Figure C).

3. Now you'll cut a hole in the lid large enough that the cat can sit inside it and use it as a litter box, but leaving enough space on the front of the lid that the cat can squat there when it's fully trained. Within the marks you made, trace a circle that you think fits the bill — I used a cooking bowl as a guide. Set the circle toward the hinge at the rear to maximize the standing space at the front of the lid.

4. Using the Dremel, cut the circle out of the lid (Figure D). Again, smooth the sharp edges.

5. Drill 3 holes through the lid and the lip of the bowl for the screws— one on each side, and one on the front (non-hinged) side of the lid. The bowl should cover the hole you cut in the lid, with its sheared-off edge facing the hinge.

6. Screw the bowl to the lid (Figure E). Seat it as snugly as possible; if it wiggles or shakes, the cat may feel insecure and not take to it as quickly. Depending on the placement of the screws, you may have to Dremel off the rest of the screw so the lid sits properly on the seat.

7. Use a corner of the sandpaper to sand down half of the topside of the lid, at the front end. This provides some texture for glue to adhere to (Figure F).

8. Glue the back of the sandpaper to the part of the lid you've textured, and let it dry. The flatter the bond, the less likely your cat will find something to object to.
9. Affix the seat and lid to your toilet, put some flushable cat litter in the bowl, and start training!

Operation

You should have your cat using this system within a month (but please see the warnings, at right).

Like most things involving animals, the idea here is simple in principle and difficult in practice; some cats will take quickly to some parts of the process and others may not. If your cat has trouble, go back a step or two until it seems comfortable.

It can be helpful to use treats to reward the cat for jumping up onto the toilet lid. As your cat gets better at this, you can delay giving it the treat until it stands on the correct part of the lid, and once it masters that, until it sits down there. This is called operant conditioning (Google "clicker training" for the latest trends in this process). Here are the basic steps:

1. Move the cat's litter box next to the toilet. If your cat is freaked out by this, move the box back to within 1' of its original location. Move it 1' closer to the bathroom every day until the box is directly up against the toilet.
2. Gradually raise the litter box by placing it on something solid and stable (like phone books); you can tape it in place to secure it. Raise it every day until it's as high as the toilet. If your cat seems comfortable jumping up into the box, speed this part of the process up. If it has trouble, go slower.
3. Move the box over onto the toilet seat and tape it down. Reduce the amount of litter in the box until it's only 1" deep.
4. Replace the litter box with the apparatus you built. Put a 1" layer of litter in the bowl.
5. Every third day or so — or whenever the cat has used the system successfully for 2 full days — Dremel off about 1" from the bowl. Cut it back from the straight cut you originally made, so that the standing surface inside the bowl gradually diminishes toward the front of the lid. This should force the cat to stand more and more on the lid and less and less in the bowl.
6. Once you've cut away all of the bowl, remove it entirely. Voilà — you have trained your cat to use the toilet. You can scatter some litter on the water to encourage your cat through this final stage.

Again, each cat will take to these stages differently. My cat skipped straight to stage 4 and then got very finicky about 5 and 6. Other cats have taken forever to recognize that the litter box had moved to another room, and then immediately started doing their business in the toilet. YMMV, so go as slow as your cat wants to — remember that cat pee smells awful and an annoyed cat can use it on your furniture at any time.

A Word of Warning

There are a few big issues to keep in mind when deciding whether to try to toilet-train your cat:

» **Don't teach your cat to flush.** Once it learns, it will find this an entertaining way to pass the time and your water bill will skyrocket.
» **Don't toilet-train if you live near a body of water where river or sea otters live.** Cat feces can contain a protozoan called *Toxoplasma gondii* that is known to kill otters.
» **This is the big one: If your cat isn't taking to the toilet within a month's time, quit trying** (at least for a few months). Domestic cats are very prone to urinary tract infections, which can kill them if left untreated. Most often these occur when a cat is holding its urine, which it's likely to do if stressed or uncomfortable with its toilet situation. Your cat may simply not be a good candidate for using the toilet, in which case it's better to let the cat have its way.

Signs of urinary tract infection include (but are not limited to):

- urinating in inappropriate places
- crying in the litter box
- frequent urination in tiny amounts
- straining to urinate
- bloody urine
- excessive genital licking

If you observe any of these signs, see your vet immediately.

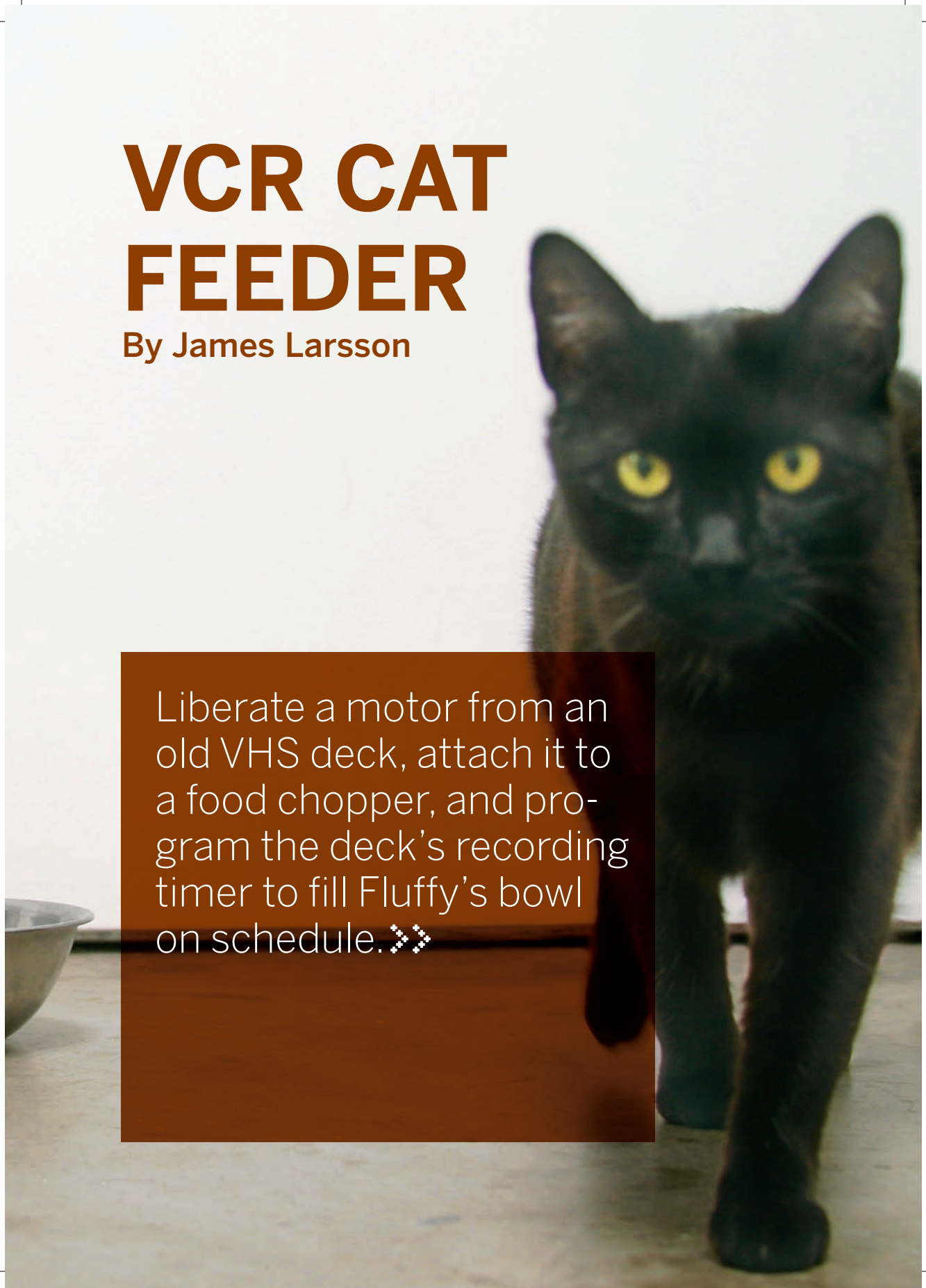
Visit makezine.com/20/diyhome_cattoilet for additional tips.

Josh Klein (www.josh.is) does systems hacking, including social networks, computer networks, institutions, consumer hardware, animal behavior, and, most recently, the publishing industry. He speaks, writes, and consults on new and emerging technologies that improve people's lives.

Photograph by Thayer Gowdy

VCR CAT FEEDER

By James Larsson



Liberate a motor from an old VHS deck, attach it to a food chopper, and program the deck's recording timer to fill Fluffy's bowl on schedule. >>

A VCR TO FEED YOUR PET

Any old VCR has a programmable timer that connects to motors for recording TV shows. This is analogous to feeding a cat, and following this principle, you can convert a VCR into a weekend pet feeder. You set the VCR's timer, and when feeding time comes, the motor that would ordinarily spin the video head operates a food delivery mechanism instead. You can even program different size portions for different days, for times when you plan on returning midday.

Pet feeders are sold commercially, but few match the versatility of a modified VCR (no matter how silly this project might sound). My feeder is based on an auger mechanism, like some vending machines. A helical shaft propels food from a hopper into the pet's bowl. You can use the same basic mechanism to drop food into a fish tank.

James Larsson is an electronics engineer and IT historian from London, for whom hardware hacking is both work and play. In addition to designing electronic equipment, he lectures and broadcasts about computer history. He also regularly performs comedy science shows, where advanced scientific principles are used to do ridiculous things.

PROGRAMMABOWL VCR: HOW IT WORKS

Cats need a regularly controlled food supply, but can otherwise look after themselves for a few days. Hijack a motor from inside an old VCR, and you can use its timer-recording system to dispense scheduled meals.

A gearbox converts the fast-spinning VCR motor to a much slower rotation with correspondingly higher torque — enough strength to turn the crank of a food chopper or other auger mechanism. Some gearboxes, like the ones shown here, reduce the rotation step-by-step with a series of planetary gears, where the box's total ratio equals the product of the gear ratios of each element. Other gearboxes, like traditional music boxes, use a single screw-shaped worm gear. You can also reduce rotation with different width spools and rubber-band pulleys.

Fed by gravity, the food chopper's auger conveys the yummies into the bowl. Depending on the mechanism, it may also do some chopping in the process.

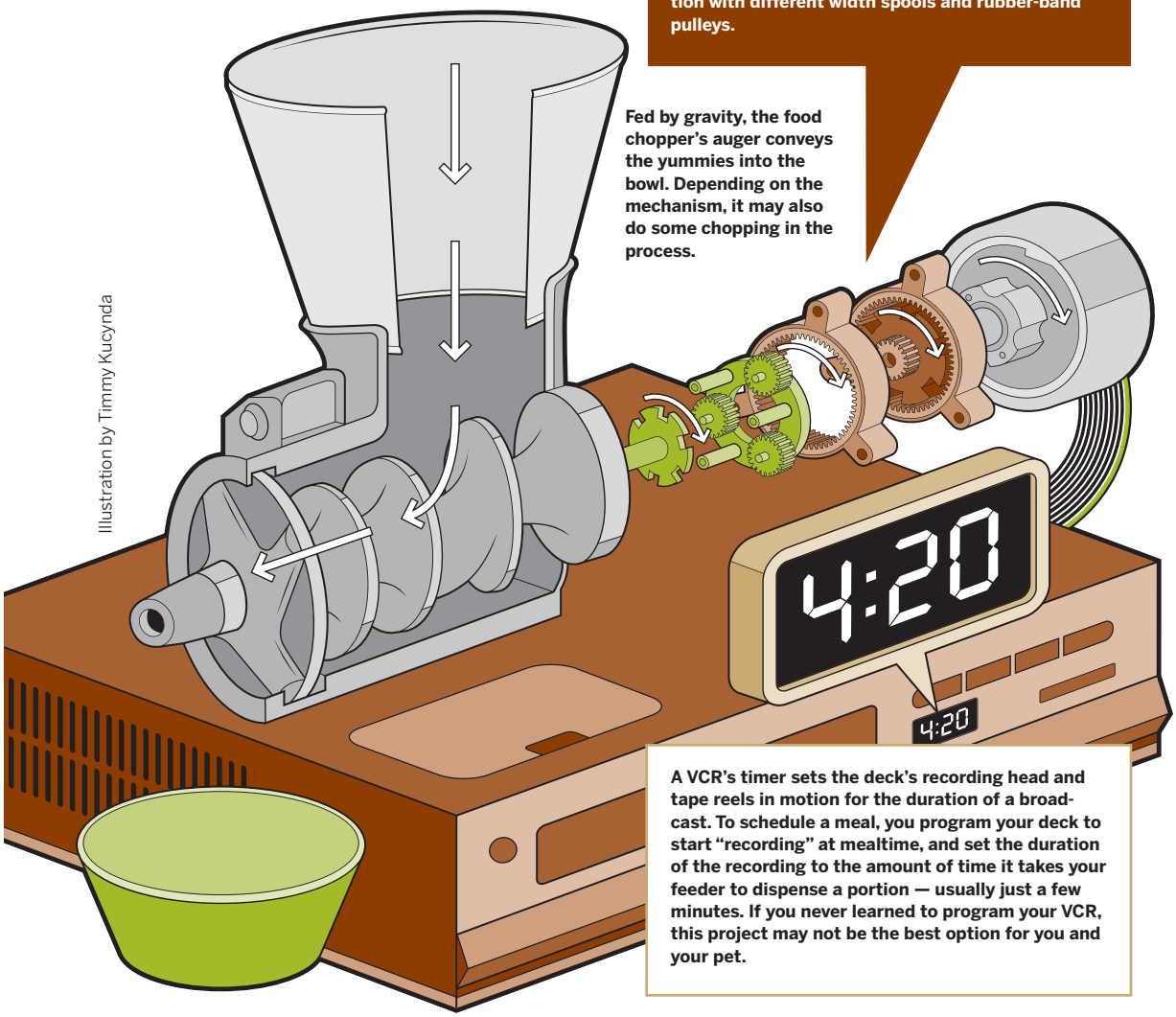
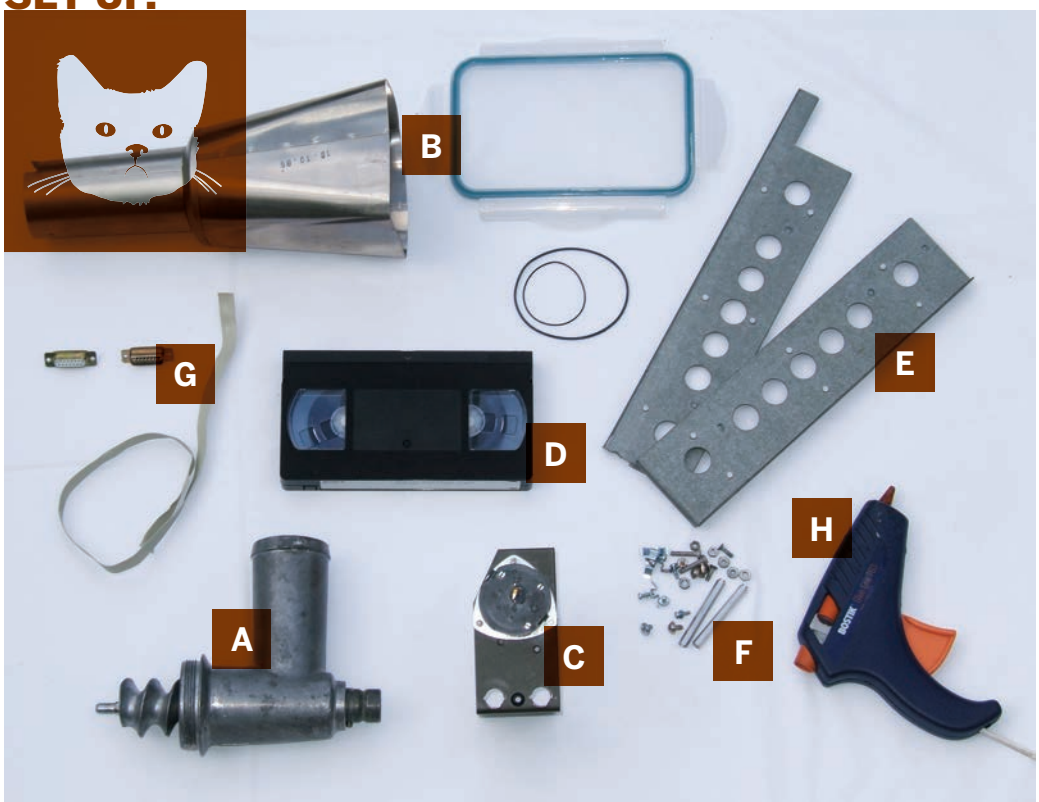


Illustration by Timmy Kucynda

A VCR's timer sets the deck's recording head and tape reels in motion for the duration of a broadcast. To schedule a meal, you program your deck to start "recording" at mealtime, and set the duration of the recording to the amount of time it takes your feeder to dispense a portion — usually just a few minutes. If you never learned to program your VCR, this project may not be the best option for you and your pet.

SET UP.



COMPONENTS

A VCR that still more-or-less works. Test the VCR first to make sure its timer and tape transport mechanisms still function, even if it doesn't produce a watchable picture. The VCR should activate its mechanism at the set time, run the tape for the set period, then stop.

If you have a choice of VCRs, go for one that you can program entirely from the front panel — this project gets cumbersome if you need to program the VCR with a remote control or via on-screen menus.

[A] Some kind of auger system. I used an old meat grinder with a helical shaft, with the cutting blades removed.

This propels the food from a container into the bowl. Make sure it works with the type of pet food you want to dispense. When choosing your auger, bear in mind that your hungry pet might try to eat, paw, or lick the system while it's in motion, and, if so, you don't want it to cause any injuries.

[B] Some kind of container that will connect with the auger system. I fashioned a sort of metal hopper head out of the magnetic shielding from an oscilloscope tube.

As with the auger, you'll need to make sure this is pet-safe — and also pet-proof. The system won't help if your cat can jump into the hopper or knock it over. I covered mine with a plastic lid, to keep the cat out.

[C] A small gearbox (or pulley system) which can reduce the standard 1800 RPM counterclockwise rotation of a video head motor into rotation suitable to drive the auger. A turn ratio of about 600:1 typically produces the right speed and torque. I used a gearbox from a defunct cam sequencer, but you can also get these from hobby retailers. Some good ones are made by Tamiya.

The "fast side" of the box must be able to couple to a shaft of approximately ½ cm in diameter. Also, make sure that the "slow side" of the gearbox can connect solidly to your auger and rotate it in the correct direction (remember the "fast side" will be going counterclockwise).

[D] A videotape you don't mind sacrificing. Make sure the recording-enable tab is unbroken.

[E] Something that can hold the assembly of auger, gearbox, and video head motor all together. I used a metal card frame.

[F] Electrical tape, nuts, bolts, screws, strong glue, etc.

[G] You might also need a multiway electrical connector and some hook-up wire. This will depend on what you find inside your VCR and how you arrange things.

TOOLS

[H] Hot glue gun

Screwdrivers

Soldering equipment

Ability to improvise

Photography by James Larsson

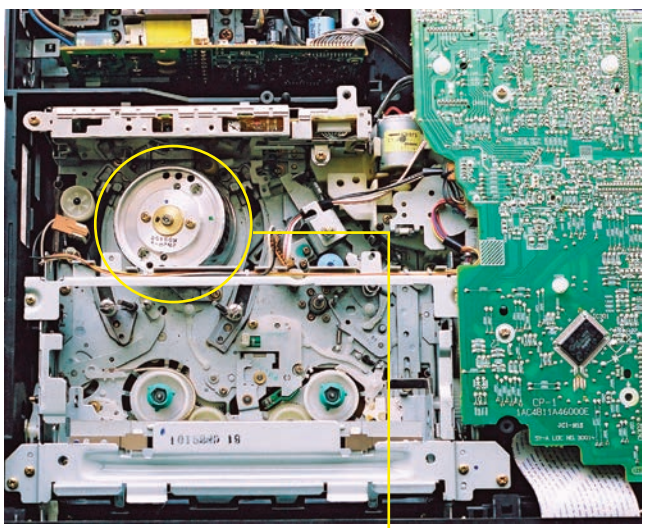
MAKE IT.

BUILD YOUR VCR CAT FEEDER

START >> **Time:** A Weekend **Complexity:** Medium to High

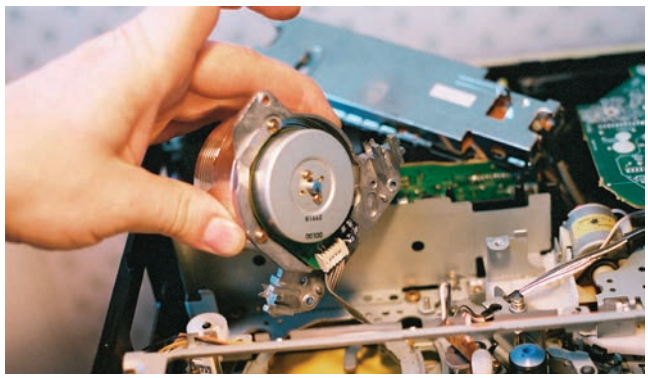
1. UNPLUG THE VCR AND OPEN IT UP. To do this, you'll probably just need a Phillips screwdriver. WARNING: As with all 110V AC-powered equipment, once you open the cover of your VCR, you are exposing yourself to the risk of serious and possibly fatal electric shock. Generally speaking, this risk is confined to the power supply and any associated switches, cables, or connectors. This article only involves the safe, low-voltage sections of a VCR. Nevertheless, it is crucial that you know WHERE NOT TO TOUCH, especially since some of the experiments involve switching on the VCR while the cover is off. It is a good idea to place some sort of insulating shield (e.g., a piece of plastic) on top of the power supply area. Hacking a VCR is only to be attempted by people with a good knowledge of electricity and its risks.

2. IDENTIFY THE VIDEO HEAD DRUM. Find the motor that drives the rotating video head drum. This motor works independently from all the other mechanical systems in a VCR, so you can disconnect it with impunity, without affecting the VCR's control systems. VCRs contain several timer-controlled motors you could use, but these other ones are often linked to sensors and interdependent systems, and their absence or misuse might stop the VCR from doing what you want. That's why I chose to use the video head motor.



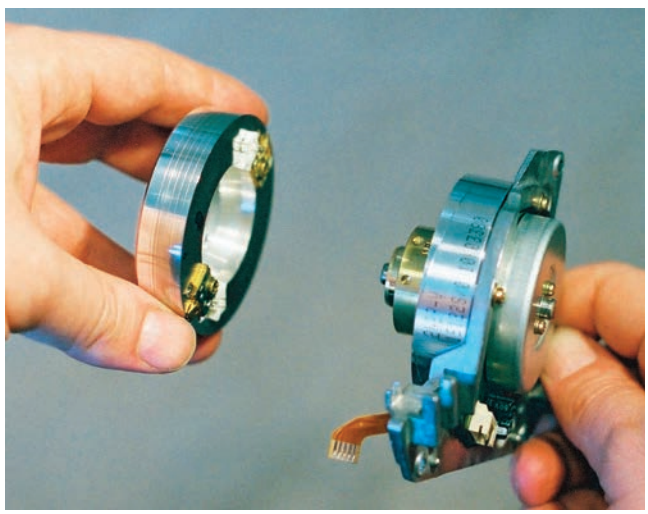
Video head drum

3. REMOVE THE VIDEO HEAD DRUM ASSEMBLY. Remove the screws that hold the video head drum assembly in place, but don't disconnect any of the wires leading to it. You'll be pulling the video head motor outside of the VCR and using it to power the auger via the gearbox.

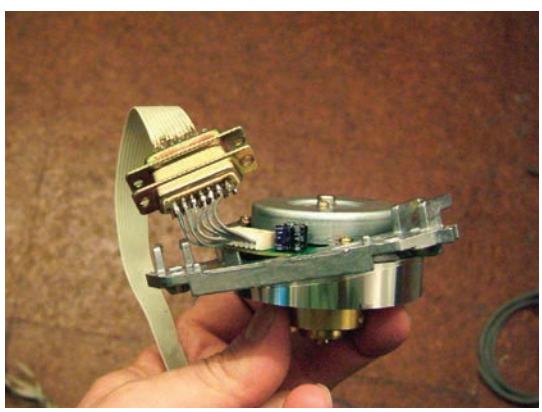


4. DETACH THE DRUM FROM THE MOTOR. To reduce the load on the motor, remove the actual video head drum. These are usually attached to the motor by screws on top, but you might have to unsolder connections to the heads.

Video head motor assemblies carry a drive system, a feedback system, and more, so they need a lot of wires. Newer models have small controllers on an integral PCB, but even with these, numerous wires still lead out to other parts of the VCR. Since all you care about is the motor, you can cut away any other wires you identify as unnecessary. They are usually the cables nearest the top of the head assembly, a short distance away from the motor connection.



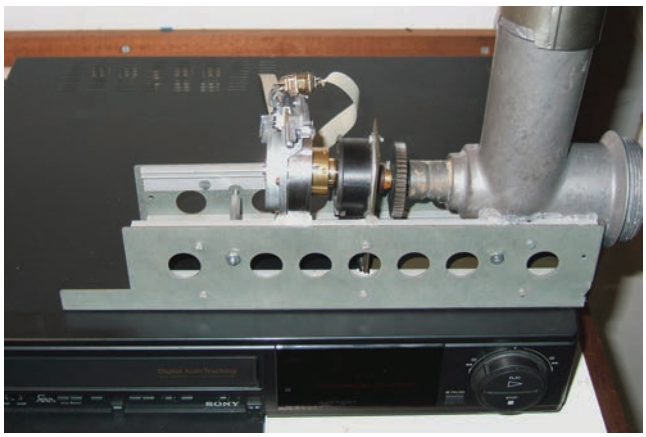
5. EXTEND THE MOTOR CONNECTIONS. You need to get the motor out of the VCR and into a location where it can drive the gearbox, and, in turn, the auger. To do this, you may have to splice some additional length into the wires that feed the motor. If so, keep the length as short as possible; I sited the whole motor/gearbox/auger/catfood assem-bly directly on top of my old VCR for this reason. It's also nice to solder in a multiway connector, so that you can unplug the feeder assembly from the VCR, thus making it easier to clean.



6. ASSEMBLE THE FEEDER. Connect the motor to the "fast side" of the gearbox. How you do this will depend on the gearbox you have chosen and the length of shaft available from your VCR's motor. For my feeder, I cut off the cog from my gearbox's original, attached the motor, and, making sure it was dead central, simply glued the VCR motor on with strong glue. Similarly, connect the "slow side" of the gearbox to the shaft of the meat grinder (or other auger mechanism). I attached the two using a cog from an old lawn mower and more glue. Finally, attach the motor/gearbox/auger assembly to whatever you're using to hold it in place. I secured it to my metal frame with a combination of bolts and glue.

7. TEST. First, make sure everything is aligned and that the couplings on each side of the gearbox turn smoothly. Power up the VCR, insert the sacrificial video tape, and press Record. Ideally, the video head motor will rotate and drive the auger. If so, you're lucky; your feeder is ready to roll. Just be sure the tape is sufficiently rewound before each use; if it reaches the end, your pet will go hungry!

Don't worry if the motor slows a bit under load, but if the motor stalls completely, the VCR's microcontroller will sense this and shut the system down, probably forcing you to switch the VCR off and then on again. If you have persistent problems with overloading, you might need to swap in a gearbox with a greater reduction ratio. Alternately, you could try using one of the other motors in the VCR. If you do this, you'll have to take into account the motor's original role, and arrange a kludge for any sensors associated with it, as discussed later.



VCRS AND TRASH TECH

VCRs have been around for about 30 years, and in that time they have gone from being suitcase-sized machines stuffed with motors, belts, and PCBs to small boxes that seem relatively empty. What you see when you take the cover off your VCR will have more to do with its age than with its brand or model. As a general rule, older machines are better for hacking. Their designs are less integrated; fewer systems are locked away in chips, and there's simply more stuff to alter and adapt.

You might simply scavenge these junked machines for individual components, but it's more interesting to use whole, functioning sections for some entirely new purpose. If you wanted to build a pet feeder from individual pieces, you'd have to assemble a power supply, a timing system, and a mechanical control system. In a VCR, not only are all of these subsystems ready-made, but they already work together. Sure, you could rip the timer out of an old VCR and use it to trigger any electrical device, but it's connected to tape transport and read-head motors — so why not base a project on more of the original machine? This high-trash approach saves effort and minimizes the number of new components you need to buy, adding to the project's trash-tech value.

Note that trash-tech projects like this one require more improvisation than ordinary construction projects, because you probably won't be using the same old VCR model that I used. You'll have to find your own way with your trash, and in some places, I can only describe the principles, theories, examples, and pitfalls, rather than give a step-by-step. Working with junk technology is rarely going to produce a device of great engineering elegance or optimal performance. Nevertheless, it's fun, interesting, and inexpensive — and it works!

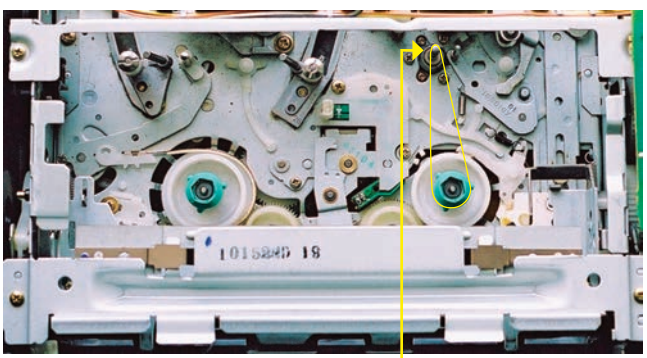
8. TRICK THE SENSORS AS NECESSARY. Your cat feeder still may not work due to its sensors reading abnormal conditions. Or you might want it to operate continuously, with no tape to rewind. The following tricks might make it work the way you want. See next page for explanations and other strategies.

Trick #1. Disassemble your sacrificial videocassette and remove the tape reels. Reassemble, cover the holes on each side with opaque tape, and load it in. If your VCR accepts this empty shell and still "records" without stopping, consider it conveniently gullible!

Trick #2. With your sacrificial videocassette partly rewound, remove its screws and reassemble it with adhesive tape. Load it into the VCR. Once it's happily loaded, unstick the tape, take the top half off, and remove the reels. If your VCR precludes you from disassembling the videocassette *in situ*, remove its windows so you can get your fingers inside.

Stretch a rubber band from the right-hand spindle to the capstan. Then press Record and see what happens. If all goes well, the spindle will turn at the correct speed and your VCR will continue "recording." If it does not, try placing another rubber band between the left-hand and right-hand spindles.

This is a fiddly operation that you won't want to repeat very often. Moreover, your VCR might need to stay powered up afterwards (so that it remembers that it's been through the tape loading procedure). Thus, you might want to finish all other aspects of your pet-feeding system and treat this as the last stage before use.



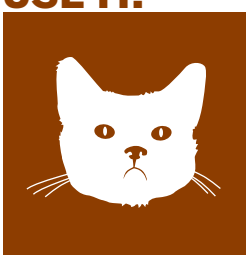
Capstan

Connect the right spindle to the capstan, and it rotates as if a tape is loaded.

FINISH X

NOW GO USE IT »

USE IT.



FEED ME.

TROUBLESHOOTING.

A typical VCR presents several obstacles to hacking attempts. Here are the most common problem sources, and ways to get around them:

Hack-resistant circuitry. Many VCR subsystems are surprisingly distributed, and some microcontrollers sense the absence of any circuitry. Don't disconnect or remove any PCBs or other systems, even if they appear to play no part in your project.

Weak signal. Some VCRs won't record a show if the signal is too weak. To avoid having to connect your pet feeder to a TV aerial, set it up to record from a (nonexistent) camera or other external line source.

Various optical sensors. These can be sensitive to ambient light, and will trigger the VCR into doing spurious things when the case is open or there's no tape inside. You may have to work in subdued light, or locate and shield all of the offending sensors.

Tape-loaded sensors. These sense the presence of the videocassette, and are usually linked with the mechanism that loads and ejects it. The easiest kludge is to load a tape or modified tape case.

Tape-end sensors. These detect the start and end of the tape using light. Put opaque adhesive tape over the two sensors that flank the cassette, or cover the corresponding holes on a cassette itself.

Recording tab sensor. This detects whether a videocassette's record-enable tab is present. It's usually a little leaf switch. Use adhesive tape to hold it in the "pressed in" position, or else connect or break the switch's contacts as appropriate.

Spindle motion sensors. These sense whether the cassette's reels are moving at a normal speed, triggering shutoff if the tape jams or breaks. The right-hand spindle always has one of these, but the left may not. One workaround is to drive spindles from the capstan by using rubber bands as pulleys.

Mode switch. This usually looks like a cog with electrical connections, and it tells the VCR's microcontroller the device's current state (Play, FF, REW, etc.). For this switch, as well as some tape-loaded and spindle motion sensors, there's too much variation among VCR models to permit any sure advice. Different models of VCR exhibit huge variations in system design and in what sorts of misuse they will tolerate. You'll just have to experiment both electrically and mechanically to get around these.

If nothing else works, try to determine what happens when an ordinary videocassette is loaded, and re-create these events by manually twiddling the spindles with your fingers, simulating the tugging that a tape would do. You'll need to observe your VCR operating, and identify which bits of the mechanism are in what position, and which internal switches, sensors or optical systems are in use. I like to think of it as a puzzle which gradually teaches you how your VCR works. And once it's done, your pet can look forward to happy days of automatic

FEEDER OPERATION.

You'll schedule feedings as timer recordings on the VCR, but first you will need to figure out how long each "recording" should last. After filling the hopper with food, put the VCR into the Record state and time how many minutes it takes for it to dispense a single portion. This is your program time. With my meat grinder auger, it takes only two minutes to fill the bowl.

KITTY TWITTY CAT TOY

By Marc de Vinck

I CAN HAS TWITTER?

Make a cheery cat toy that sends tweets, and let your cat join the millions of other Twitter-critters who update the world regularly with their activities.

About 2 months ago, after years of begging and pleading from my family, I reluctantly agreed to get another cat from the local shelter. We already have a menagerie of beasts that share our home, but for some reason they felt we needed another.

I admit, I do like our new addition to the family. Chester is a spunky little stray who's always looking for fun. Even if it means knocking a few things off my desk as I write this article. The only problem is, when my wife goes in to work, she misses her new cat and always wants to know his whereabouts.

She used to ask me for updates, but after a while I realized that I needed to make something that would take me out of the loop, and let the cat communicate with my wife directly via twitter.com. I needed a Twittering cat toy. And that's how Kitty Twitty came to fruition, after some basic soldering and crafting with just a few parts.

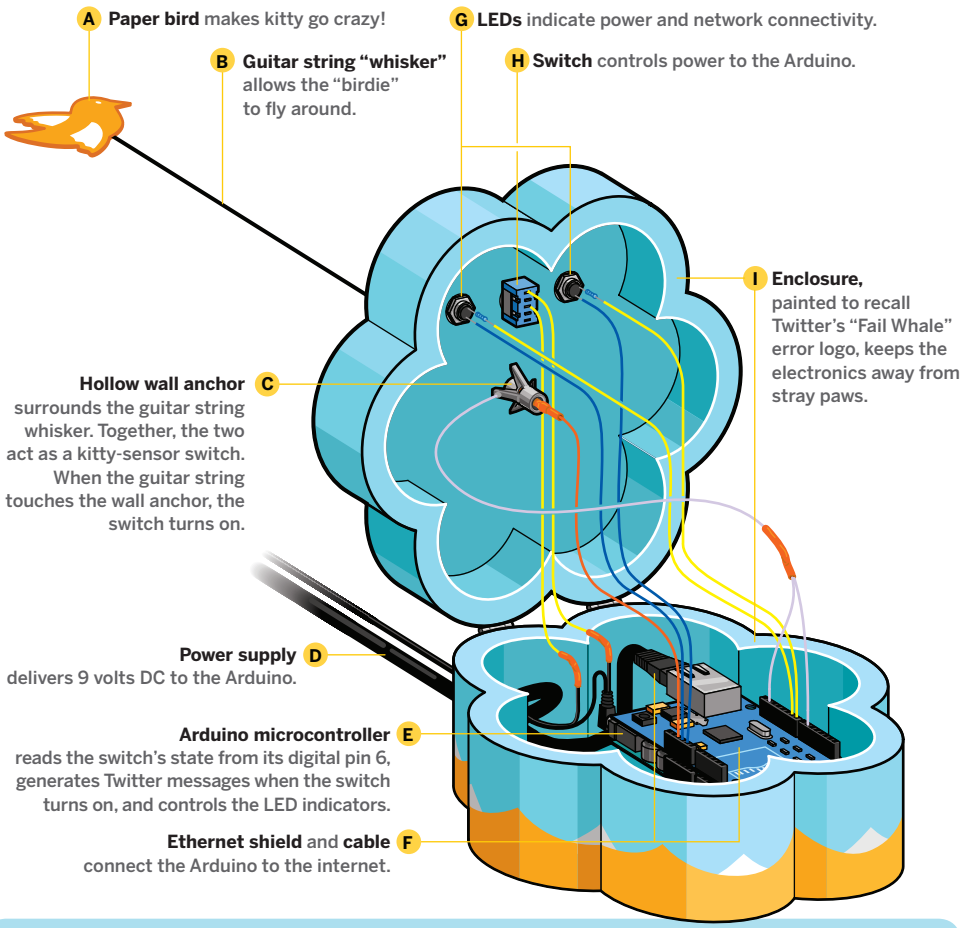
Photography by Marc de Vinck

Marc de Vinck moonlights as an artist creating interactive sculpture from his studio in the Northeast. He is a member of the MAKE Advisory Board, a contributing writer for MAKE, and the product curator for the Maker Shed.

Kitty Twitty: HOW IT WORKS

Kitty Twitty senses and Twitters felinogenic perturbations to its cat-attracting whisker.

BONUS! Papercraft bird costumes for your Kitty Twitty! makezine.com/22/kittytwitty



Software

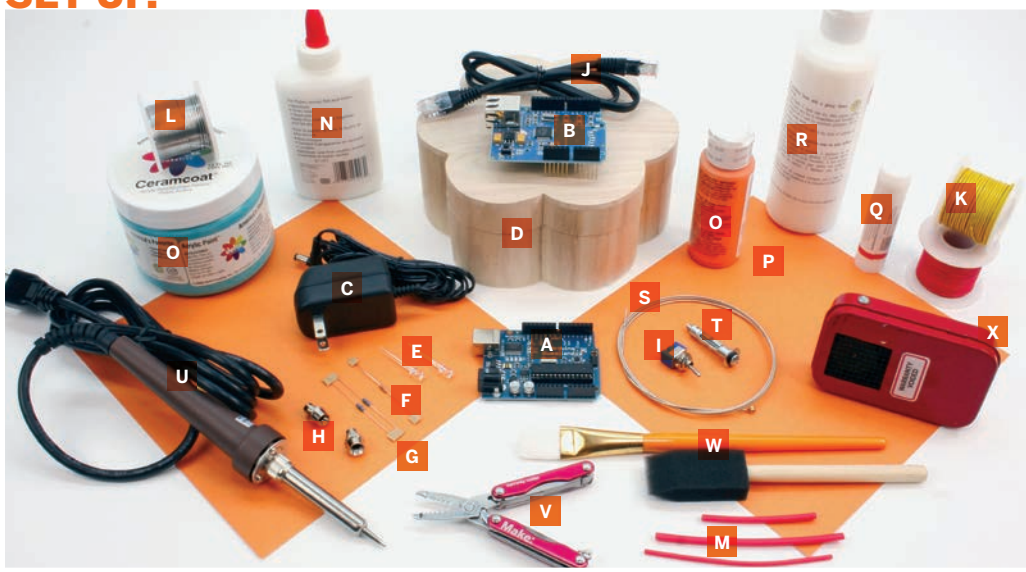
The Arduino code generates semi-random Twitter messages of the form, *Chester loves Kitty Twitty! Meow!* or *Monster cat attacked Kitty Twitty! Mwaha-haha!*, where the subject refers to the cat, the direct object is always "Kitty Twitty," and the tweet ends with an exclamation from the cat's point of view.

The sentences are varied because Twitter filters out identical, repeated tweets. Generating a unique sentence each time circumvents this block (and is more fun).

Another limit imposed by Twitter is a maximum of 150 tweets per hour (tph). So the code adds a 30-second delay after each send, effectively keeping Kitty Twitty's tweetrate under 120tph.

Illustration by Rob Nance

SET UP.



MATERIALS

[A] Arduino Duemilanove item #MKSP4 from the Maker Shed (makershed.com)

[B] Arduino Ethernet Shield Maker Shed #MKSP7

[C] 9-volt power supply Maker Shed #MKSF3. Or use a 9V battery with a center-positive 5.5mm×2.1mm barrel connector, especially if your cat chews on wires.

[D] Enclosure This can be almost anything, as long as the Arduino and Ethernet Shield fit inside. Also, since your cat will be playing with it, no glass or toxic paints, and the heavier the better. I used a $6 wooden box from a local craft store.

From an electronics supplier, such as Digi-Key, Mouser, or RadioShack:

[E] LEDs: green (1) and blue (1)

[F] Resistor, 10kΩ

[G] Resistors, 220Ω (2) or other value matched to lighting your LEDs with 5V DC

[H] LED holders (2)

[I] SPST switch I used a sub-mini toggle, RadioShack part #275-0612.

[J] Ethernet cable

[K] Solid-core wire, 22 gauge, 2'–3', various colors

[L] Solder, rosin-core

[M] Heat-shrink tubing, ⅛" diameter

From a craft store:

[N] Craft glue, nontoxic

[O] Paint, nontoxic

[P] Paper, various colors

[Q] Glue stick

[R] Nontoxic sealer (optional)

[S] Guitar E string or similar steel wire

[T] Hollow wall anchor, medium duty, metal #6-32×1½" or similar, from a hardware store

TOOLS

[U] Soldering iron

[V] MAKE: Warranty Voider Leatherman "Squirt" E4 #MKWVE4 from the Maker Shed. Or you can use standard cutting pliers and needlenose pliers.

[W] Paintbrushes

[X] Fume extractor (optional) but highly recommended, for your respiratory health when soldering. To make your own, see MAKE Volume 19, page 123.

[NOT SHOWN]

Computer running Arduino software free download at arduino.cc

USB A-B cable for programming the Arduino. Borrow one from your printer.

Drill and drill bits: ⅛", ⅝", ½" spade My LED holders and switch needed ⅝" holes; yours may vary.

Phillips screwdriver

Pencil and eraser

Scissors

Binder clips, various sizes (optional)

MAKE IT.

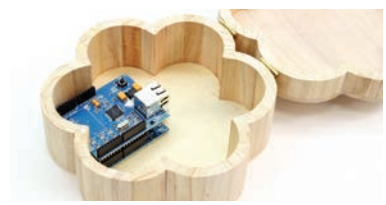
BUILD YOUR KITTY TWITTY

START **Time:** 1 Day **Complexity:** Moderate

1. DRILL AND PAINT THE ENCLOSURE

Chester doesn't get too aggressive with the Kitty Twitty, but if he ever does, I'll add some weight to the enclosure to help keep it upright.

1a. Decide where to drill the hole for the power and Ethernet cables. Attach the Ethernet shield on top of the Arduino and place them in the box to see where they fit best. Mark the location of the hole with a pencil on the outside of the box.



1b. Use a ½" spade bit to drill the hole, and go slow to minimize splintering. Once the hole is drilled, give it a quick test-fit. Does it fit? Yes? Good!

1c. Mark the 4 holes where you want to mount the 2 LED holders, the power switch, and the hollow wall anchor. The wall anchor should be in the center.

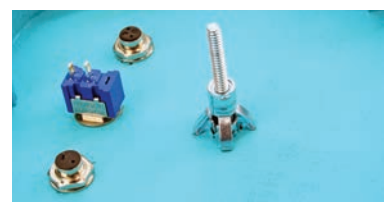
1d. Drill small pilot holes at each location (⅛" should work) and then drill out the holes to fit the components.

1e. Test-fit the components, but don't permanently attach anything yet.

1f. Decorate! I marked out my design in pencil and then painted it with kitty-safe nontoxic paint. Don't forget to paint the inside; you'll want to show your friends how it works, and having a painted inside looks so much cooler!

1g. After the paint dries, attach the LED holders and the switch to their respective holes. A few nuts and washers, and it's done.

1h. Finally, attach the hollow wall anchor. Screw it in slowly to avoid damaging the wood, and don't overtighten. The anchor will fold up on itself and its "legs" will secure it against the inside of the box, but they shouldn't dig into the surface. Once the anchor is in place, remove the screw.



2. MAKE THE SENSOR

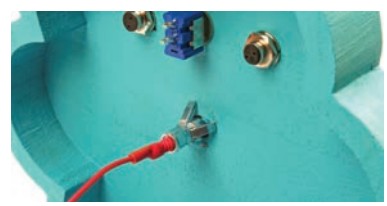
2a. Cut the guitar string to about 10"–12", keeping the lug end (with the little brass barrel). The lug will prevent the wire from being pulled out by an aggressive kitty. If you're using plain steel wire, tie a knot instead.

2b. Use small pliers to curl the cut end around, so it will attach to the toy more easily and won't expose the cat to being poked with a sharp wire.

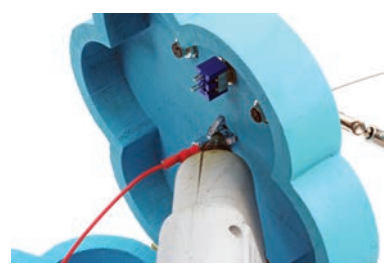
2c. To electrically insulate the guitar wire from the wall anchor, cut two ½"-long pieces of ⅛" heat-shrink tubing, then slip and shrink them one by one over the wire at the lug end.

2d. Solder a 6" length of insulated solid-core wire (I chose red) to the brass lug grommet, extended away from the guitar string, and encase the entire connection in another piece of heat-shrink.

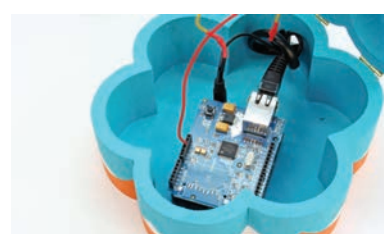
2e. Thread the guitar string through the underside of the hollow wall anchor and screw in the wad of heat-shrink. It's OK if it's a tight fit; my heat-shrink even twisted a bit, which made for a nice fit. But make sure the wires and lug do not make any metal-to-metal contact with the anchor.



2f. While keeping the guitar string centered (I used a "third hand" but you could have a friend hold it steady), apply some hot glue into the core of the hollow wall anchor around the string. You don't want to fill the entire cavity, just a bit around the bottom to further insulate the guitar string and keep it straight and secure. If you add too much hot glue, the wire won't be able to flex enough to touch the top of the anchor, so err on the side of caution and use only a dab or two.



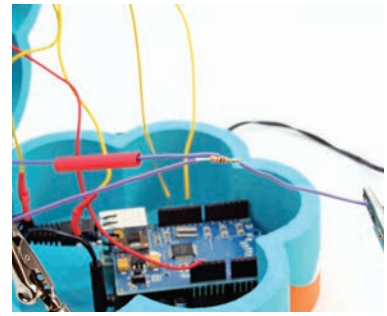
2g. Feed the Ethernet and power cables through the hole you drilled in Step 1b. Tie a simple knot to keep them from being pulled out of the box. Position the Arduino boards in the box, plug in both cables, and also plug the red wire from the guitar string into its 5V header socket.



2h. On the lid of the box, solder a 3"–4" piece of wire to one of the anchor's legs. Using a different color wire (purple here) will help. The anchor draws a lot of heat away, so you'll need to heat it with the soldering iron for a while, or else the solder will bead up and you won't get a good joint.

2i. Now we'll split the connection from the hollow wall anchor so that one wire goes to an Arduino ground pin (GND) through a 10kΩ resistor, and the other wire connects to its digital I/O pin 6. Doing this pulls pin 6 to ground, so that it reads LOW unless contact is made by the sensor.

Strip, twist, and solder a wire to the end of the anchor wire, along with one end of the pull-down resistor. Then solder a third wire to the other end of the resistor, and insulate the entire junction with a long piece of heat-shrink. Make sure you can identify which lead runs to the resistor and which goes directly to the anchor.

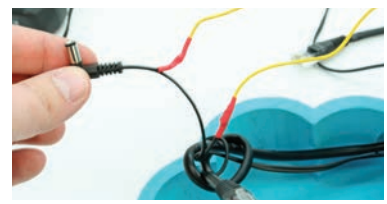


3. WIRE THE SWITCH AND LEDS

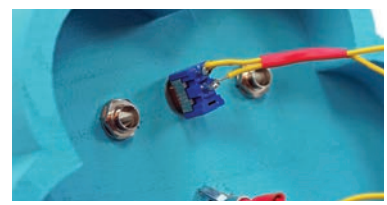
3a. Unplug the power supply cord at both ends, and then cut and strip one of its wires about 2" from the barrel plug end.

3b. Solder a piece of wire to each end of the cut wire, and seal both connections with some heat-shrink tubing.

TIP: Electrical tape will work too, but I find that using heat-shrink makes for a more permanent solution.



3c. Solder the free ends of the wires you just attached to the 2 terminals of your switch. No need to worry about the polarity; either way works.



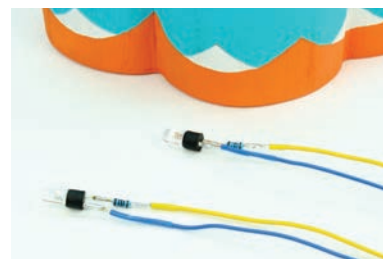
3d. If you're using LED holders, remove their rubber grommets and insert an LED into each. Make sure you know which color LED is which.

TIP: If your LED is clear, you can verify its color by pressing its leads around a 3V coin-cell battery (CR2032), longer lead on the positive (+) side of the battery and shorter on the negative (–).

3e. For each LED, solder a 220Ω resistor (or similar value) between the positive (longer) lead and a 3"–4" length of wire. The resistor limits the amount of current that flows through the LED, so that it won't burn out. Solder a 3"–4" wire of a different color to each negative lead. I used yellow for positive and blue for negative, but red and black are traditional.

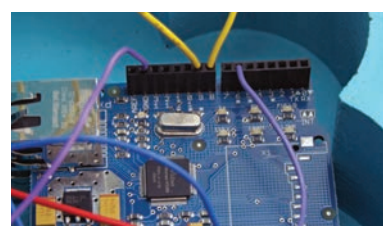
NOTE: If your enclosure is shallow, you may need to trim the LED leads before soldering so that the lid will close. Cut them at an angle to retain the different lengths that indicate (+/–) polarity.

3f. Insulate all connections with heat-shrink tubing (I used clear heat-shrink here) or electrical tape.

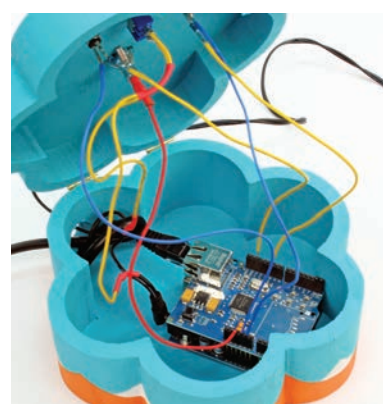


4. CONNECT EVERYTHING

4a. Fit the LEDs into their holders. Plug their negative leads into 2 ground (GND) header pins on the Arduino. Plug the positive lead of the blue LED into digital pin 8 of the Arduino and the positive lead of the green LED into pin 9.



4b. To wire the split lead from the wall anchor, plug the lead without the resistor into Arduino digital pin 6, and the resistor lead into ground. All done!



5. MAKE THE PAPER TOY

Kitty-wise, the most important part of this build is the actual toy that the cat plays with. You can use almost anything, from a feather or piece of cardboard to a lightweight manufactured toy. Just make sure the materials are 100% kitty friendly. And you can enhance your kitty's fun by adding some catnip!

5a. Draw a bird, or whatever you think might interest your kitty, onto a piece of paper. Once you have your final design, tape 2 pieces of paper together and cut the design out of both, to make 2 mirror images. I decided to add a few white paper highlights, and you could easily add additional detail with nontoxic markers.

5b. Add plenty of nontoxic glue to one side of a paper bird. Center the guitar wire loop in the middle, and then add the other bird cutout to the opposite side to create a paper-wire-paper birdie sandwich.

5c. Press the birdie between books or in binder clips while the glue dries. I decided to clip it and let it sit overnight. The end result was a durable and appealing birdie for my cat to attack!

NOTE: Go to makezine.com/22/kittytwitty to download papercraft bird costumes for your Kitty Twitty.

6. SET UP THE SOFTWARE

6a. Sign up for a new Twitter account (twitter.com), following the instructions to create a username and password. It's simple and free!

6b. Download and install the Arduino software (arduino.cc/en/Main/Software).

6c. Download and install NeoCat's Twitter Library for Arduino (arduino.cc/playground/Code/TwitterLibrary), which makes it easy for the code to connect to Twitter.

6d. Download and install Tom Igoe's String library (formerly TextString; arduino.cc/en/Tutorial/TextString), which simplifies the code to assemble random sentences.

6e. Download and install NeoCat's Twitter Library for Arduino (http://playground.arduino.cc/Code/TwitterLibrary, which makes it easy for the code to connect to Twitter).

Copy the Kitty Twitty source code (https://pastebin.com/KU8Dc7W5) and paste it into a new sketch.

You'll use http://arduino-tweet.appspot.com as a proxy server to authorize your tweets using a token generated for your account. Generate your token and replace it in the following line in the code:

```
Twitter twitter("YourTokenHere");
```

6f. To configure the network information in the code, find this section of code and replace the `ip`, `gateway`, and `subnet` values with your own values.

```
byte ip[] = { 192, 168, 2, 7 };                 // a free IP address on your network
byte gateway[] = { 192, 168, 2, 1 };            // the gateway address of your network
byte subnet[] = { 255, 255, 255, 0 };           // the subnet mask of your network
```

To get these settings, start by looking at your computer's network settings. On a Mac, go to System Preferences/Network, then click the Advanced button and select the TCP/IP tab. On a PC, go to Start/Control Panel/Network and Sharing Center, then click View Status and Details.

For the code's free IP address, you can usually just take your network setting and increase the last number a little bit. In my case, my computer's address is `192.168.2.6`, so I tried `192.168.2.12` and it worked fine.

Next is the gateway address. On a Mac, this is listed as Router and on a PC, it's listed as Default Gateway. Mine is `192.168.2.1`. The subnet mask is generally `255.255.255.0`, but yours may be different, and it will also be listed in with your computer's network config information.

6g. Save the revised code, then upload it to your Arduino. With the Arduino environment already configured to recognize your port and board, this usually means just plugging it into your computer and clicking the Upload button. But if you're not sure how to do this, the Arduino website (arduino.cc/en/Guide/HomePage) has great tutorials, and the Resources section on the next page lists other ways to get started.

TIP: If you have trouble with any of the software setup, try posting in the MAKE forums (forums.makezine.com). They're filled with friendly and helpful people.

FINISH X

USE IT.

START SPREADING THE MEWS

OPERATION

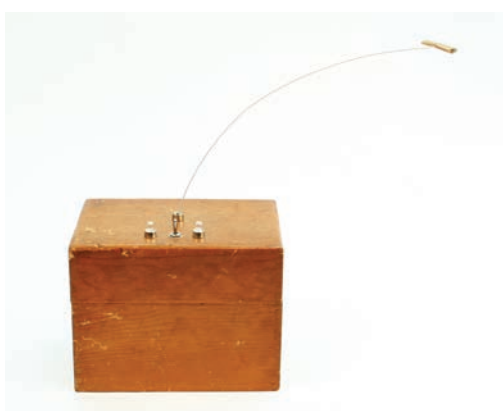
This is really easy. Simply plug in the power supply and Ethernet cable, and flip the switch. The green power LED should come on, and in a few seconds, the blue network status LED, too. The code tweets an "Up and Running" message to let you know everything is OK. You can plug a USB cable into the Arduino and listen in on the serial port for some debugging.

Every time the wire makes a connection, you'll see a new tweet! That's it!

VARIATIONS

You can modify this project to make almost anything send a tweet. It's a cat toy, but there's no reason it can't be converted into a Twittering dog toy, or even a Twittering bird perch. Just substitute a different kind of switch sensor for the bird-on-a-wire. Make a Twittering burglar alarm? Easy! Doggie door? Sure! Twittering fish? Now that's a challenge!

Also, you can add additional switches or sensors, connect them to as-yet-unused pins on the Arduino, and write some code to handle them. Think about adding a servo to make some random rumbles, or



a speaker to simulate a bird. That should keep your cat's interest!

This project is still evolving, and I need to add more parts and experiment with them before I settle on the final Twittering toy. By the time you read this, I hope to have modifications that check whether your cat is sleeping or needs food, via pressure-sensitive piezos under its bed and food bowl. I also plan to add a speaker or small motor to get the cat's attention. See makezine.com/22/kittytwitty to learn more about these modifications.

RESOURCES

KittyTwitty project code, links, and other resources: makezine.com/22/kittytwitty

Arduino tutorials: arduino.cc/en/Guide/HomePage

Getting Started with Arduino by Massimo Banzi: Maker Shed item #9780596155513, makershed.com

Making Things Talk by Tom Igoe: Maker Shed item #0596510519

DOUBLE PENDULUM

By William Gurstelle

CHAOS ON A STICK

Devices that demonstrate true chaotic behavior (in a strict mathematical sense) are rare. Even rarer are chaotic devices that are easy enough for the typical maker to build at home and are interesting and beautiful. But one device nicely fits the bill: the double pendulum.

A double pendulum consists of a bar swinging from a pivot, with a second pendulum attached to the first bar's end. While the double pendulum is a simple physical system, you'd be hard pressed to find another device this simple that exhibits so wide a range of behavior. Give it a little push and the motion is fairly predictable. But give it a bigger push — bingo, welcome to chaos!

The double pendulum described here was designed with several options for demonstrating a variety of chaotic motions. With the right mounting, it's an interesting if not downright charming display that fits well into a number of settings, including classrooms, laboratories, and homes.

Photograph by Sam Murphy

William Gurstelle (bill@makezine.com) is a MAKE contributing editor and the author of the book *Absinthe and Flamethrowers: Projects and Ruminations on the Art of Living Dangerously*.

Swing Thing

The Simple, Made Complex

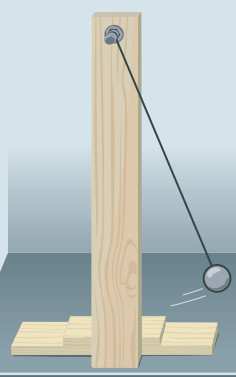
What exactly is chaos? It means different things in different contexts. In common discourse, it means a confused, disordered state of affairs.

To the mathematician or physicist, chaos does not mean arbitrary or random motions and systems, nor does it mean that the outputs of a system are unrelated to its inputs. It does mean that the behavior of a system is, in a practical sense, unpredictable because small differences in initial conditions result in huge differences in subsequent actions. In a chaotic system — like the proverbial Amazon butterfly whose wing-fluttering can affect the weather in Europe — cause and effect are related but the complexity of the system makes accurate predictions impossible.

James Yorke of the University of Maryland is the mathematician who first introduced the term *chaos theory*. "The motion of a double pendulum," he says, "gets pretty complicated. But that's what chaos is."

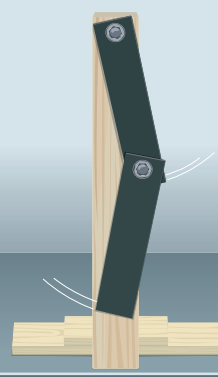
"[The pendulum is] predictable in the short run but not in the long run," said Yorke in a recent *Washington Post* interview. "Chaos is about lack of predictability. Obviously, the spin of the pendulum is determined by physical laws, but it's very hard to predict because very small changes in the spin cause very big changes in the output."

Simple: Single Pendulum



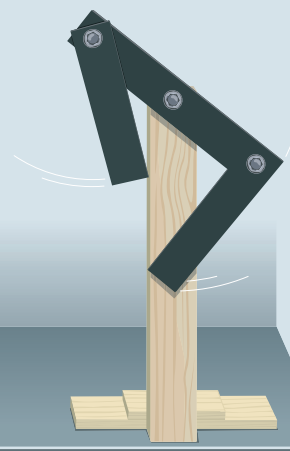
Galileo Galilei became interested in pendulums as a university student in Pisa in the 1580s, when he observed a lamp swinging to and fro in a cathedral. His experiments led to his discovery in 1602 that the amount of time it takes for a simple pendulum to swing back and forth is dependent on the length of the pendulum, and not dependent on the weight of the bob or the size of the swing. A half-century later the scientist Christiaan Huygens made use of this feature, known as *isochronism*, by inventing the pendulum clock, which is still in use today.

Chaotic: Double Pendulum



The double pendulum doesn't exhibit isochronism. Though its construction is very simple, its motion is chaotic and impossible to predict, because very small changes in friction, initial drop height, temperature, and other variables have a large effect on its behavior over time. This sensitivity to initial conditions makes the double pendulum interesting to watch, as its pattern of movement is always changing.

Simple or Chaotic: Rott's Pendulum



In this configuration, first analyzed in 1970 by Swiss physicist Nikolaus Rott, a right-angled main pendulum joins a smaller side pendulum, and their 2 pivots are aligned horizontally at rest. When given a gentle push, the 2 arms will move in resonance with one another — but only if the ratio between their fundamental frequencies is 1:2.

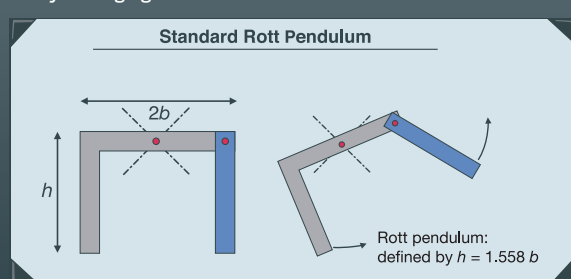
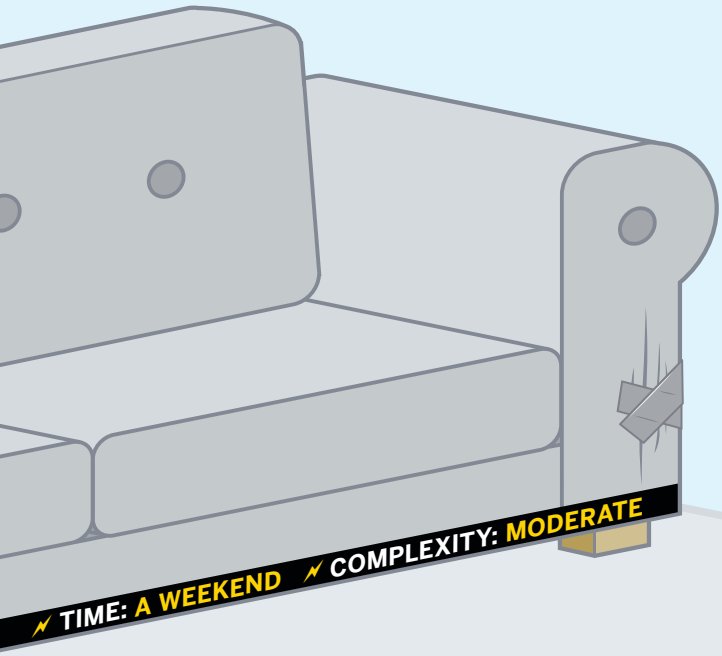


Illustration by Tim Lillis



TIME: A WEEKEND COMPLEXITY: MODERATE

Cat Scratch Feeder

Build a snack-dispensing scratching post that will make Kitty forget the couch and curtains.

Written and photographed by ***Phil Bowie and Larry Cotton***

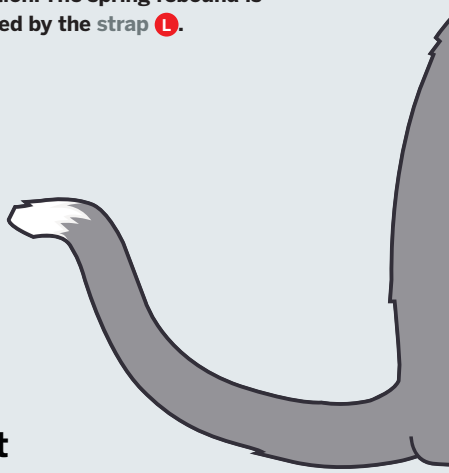
Has your cat left scratch marks on everything from grandmother's kneecaps to your grandfather clock? It's time to train Kitty to use this scratching post instead of everything else in your home.

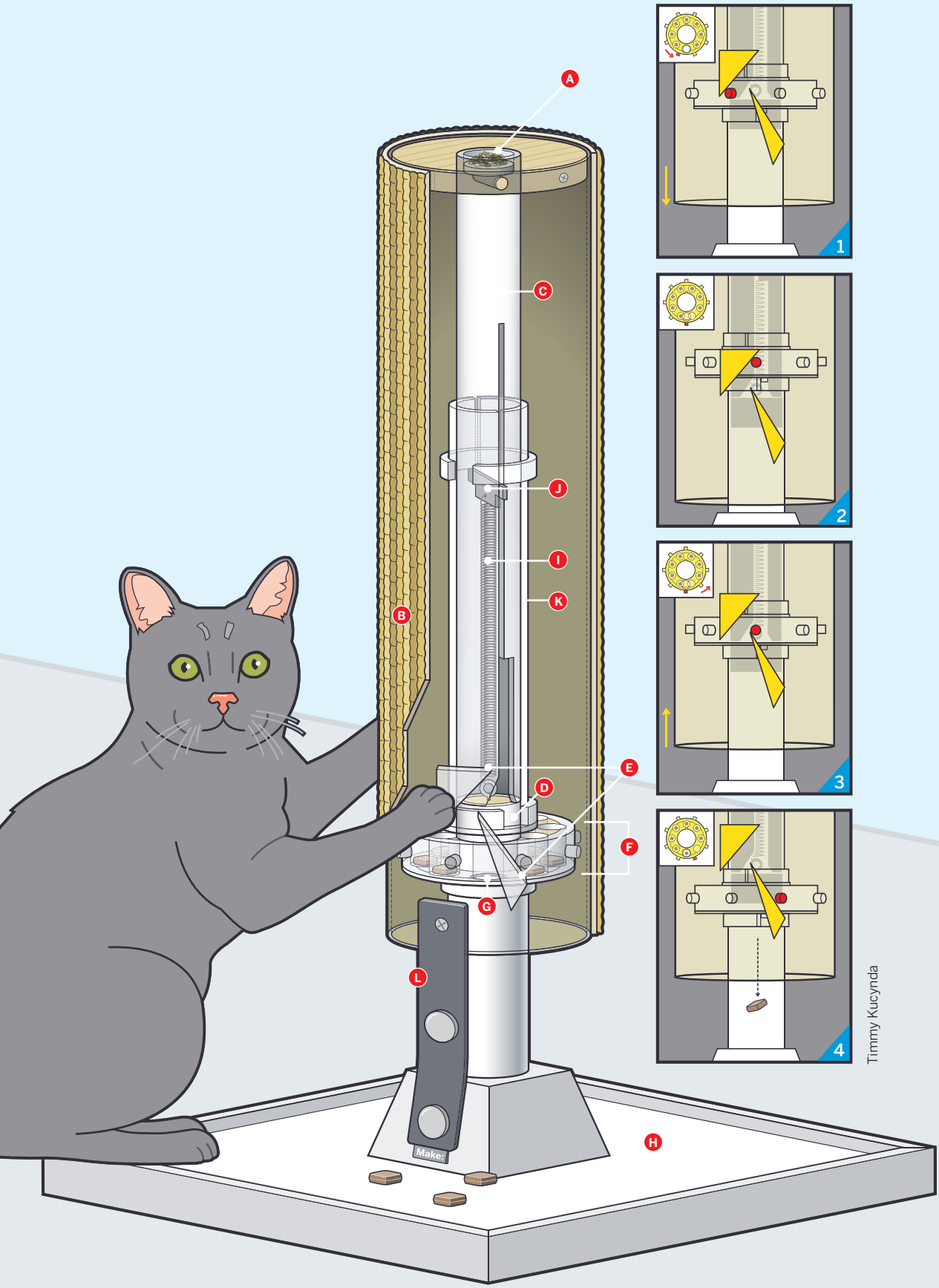
A catnip cup in the top will attract your cat and place her in natural scratching position. Each time the cat claws downward on the spring-loaded carpeted cylinder, this device will deliver up to 4 special treats. Because you control the number of treats, you can keep your cat lean and gradually wean her off the treats altogether as she becomes accustomed to using the post, if you wish.

A catnip cup (A) attracts the cat to pull down on a carpeted scratch cylinder (B) causing the inner tube (C) to press down on a plunger (D) and also causing the wedges (E) to engage rotation pegs.

Pegs rotate a treat turntable (F) which releases treats through a hole in the treat disk (G) whence they fall onto a base tray (H) to reward the cat.

A spring (I) attached to a retainer (J) in the support tube (K) pulls the plunger back up, raising the scratch cylinder to the starting position. The spring rebound is limited by the strap (L).




A
C
J
I
K
B
E
D
F
G
L
H
Make:
1
2
3
4
Timmy Kucynda

Materials & Tools

Berber carpet scrap 15"×16"

Dowel, wood ¼" diameter, 2" length

Aluminum flat bar ⅛"×½"×2" long

Dowel, acrylic ¼" diameter, 6" length

Softwood lumber 2×4 nominal, 12" length actually measures 1½"×3½"

Extension spring 0.44"×10.25"×0.040", working load 1.4lb such as Hillman #222, from Lowe's. You'll cut it to 5¼", so shorter versions will work if you can find them.

PVC pipe Schedule 40, 1" nominal, 1.315" OD, 0.133" wall thickness, 15" length The outer diameter is almost exactly 1 5/16", the wall thickness between ⅛" and 9/64". For a table of typical PVC dimensions see makezine.com/go/pvcdims.

Fabric strap non-stretching, ¾" or 1" wide, 5¼" length

PVC pipe sewer & drain type, 4" nominal, 0.08" wall thickness, 18" length

PVC pipe Schedule 40, 3" nominal, 3½" OD, 0.216" wall thickness, 12" length

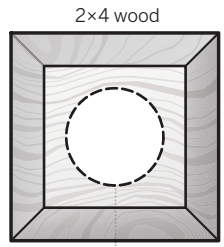
PVC pipe Schedule 40, 1¼" nominal, 1.660" OD, 0.140" wall thickness, 18" length This is approximately 1⅝" OD, 1⅜" ID, 9/64" wall thickness.

- **Softwood shelving board, ¾"×11½"×18"**
- **Softwood strip, ¼"×1"×50"**
- **Softwood or plywood, ½"×4"×6"** for top disk
- **Screw eye, small**
- **HDPE (high-density polyethylene) sheet, 2mm** We found 90mm disks on eBay that were perfect. You could also use furniture sliders or similar plastic material.
- **Fabric snaps, ⅝" OD (2)** such as Dritz, available as a kit
- **Various screws and brads**
- **Table saw** You can do this project with hand tools, but power tools will be more accurate and save time.
- **Band saw**
- **Center punch**
- **Drill press**
- **Handheld drill**
- **Drill bits** including spade bits and an adjustable (fly cutter) bit
- **Power sander and sandpaper**
- **Hammer, small**
- **Pliers: needlenose and side cutting**
- **Metal-cutting shears**
- **Screwdrivers**
- **Files**
- **Square, small**
- **Hot glue gun**
- **Glues: wood glue, hot glue, cyanoacrylate glue (aka super glue), and spray adhesive**
- **Scrap wood** for V-block and other drilling/sawing jigs

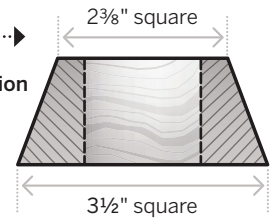
Gunther Kirsch

1a **Base & edging**

1b **Support tube holder**

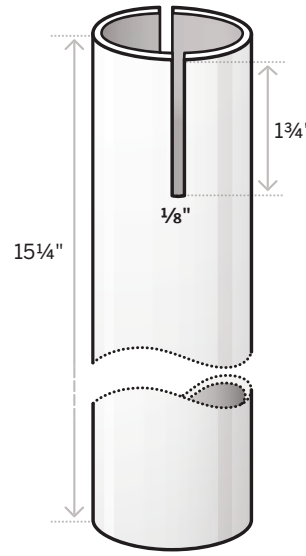


Hole: Drill using 1⅝" fly cutter bit

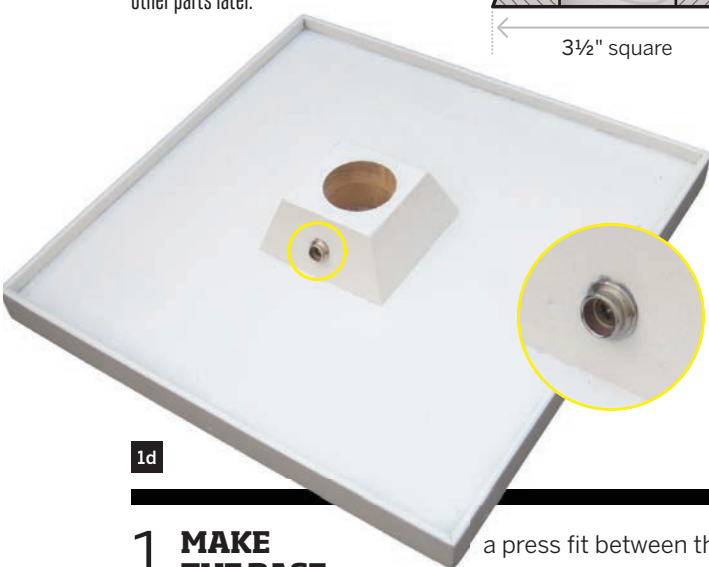


NOTE Keep your adjustable bit set at 15/16" diameter for drilling other parts later.

2a **Support tube**



PVC tubing 1⅝" OD, ⅜₆₄" wall



1d

1. MAKE THE BASE

1a. Cut the base square, mitering ¼" wood strips so they form a lip all around to help retain the dispensed treats. Fasten with brads and a bit of wood glue.

1b. Follow the support tube holder diagram to build the holder. For safety, drill the hole with a fly cutter before cutting the wood to size. The hole is nominally 1⅝", but drill it slightly undersize to ensure a press fit between the holder and the support tube.

Chamfer the holder's edges on a table saw or band saw.

1c. Fasten the support tube holder to the center of the base with wood screws.

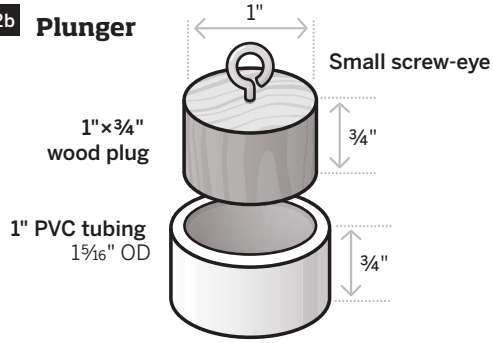
1d. Insert a stub of 1¼" PVC pipe (1⅝"-OD) into the hole as a mask, then sand, prime, and paint the base a light color so the cat treats will show up on it.

Attach a male fabric snap to the center of any face of the holder with a wood screw.

2. MAKE THE SUPPORT TUBE COMPONENTS

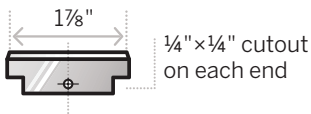
2a. Cut the support tube from 1¼" PVC pipe, using a table saw, following the diagram. To cut the slot in the center of one end, hold the pipe vertically and use wooden pushers at the bottom and side as shown (ask a friend to help).

2b Plunger



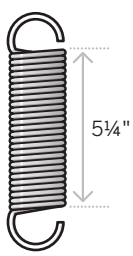
2c Top spring retainer

Make from ½"-wide aluminum.



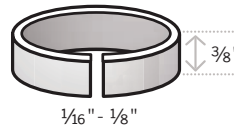
Drill 1/16" hole on centerline, ⅛" from bottom.

2d Spring

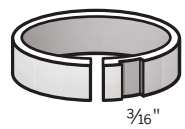


2e Split ring

Make 3 from 1¼" PVC.



Notch one ring near split, approx. half material thickness deep.



2b. Make the plunger from 1" PVC pipe, following the plunger diagram. Cut the 1"-diameter wood disk on a band saw, sand it to fit tightly in the ring, and glue it in place. Sand the top and bottom of the plunger flat and square, then insert a small screw eye in the center of one face.

2c. Make the top spring retainer from the aluminum bar, following the diagram, using a band saw. For safety, drill the hole and notch the corners before cutting the part to final size.

2d. Cut the extension spring down to 5¼" over the closed coils, per the spring diagram. Use needlenose pliers to bend out new hook coils on the ends, then cut them with side-cutting pliers. Insert the hook coils into the top spring retainer and the plunger screw eye. Then insert that assembly into the support tube per the assembly diagram in step 4 on page 114.

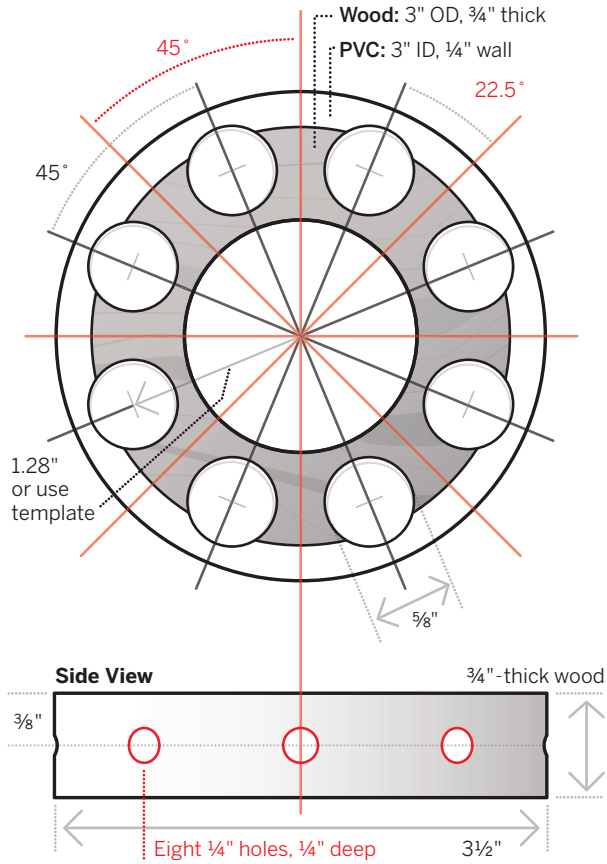
2e. Make 3 split rings from 1¼" PVC pipe per the split ring diagram.

Note that one has a notch in its outside surface near the split, which can be rough-cut with a band saw, and the inside corners filed square.

Put the top spring retainer in place. Then, expand one of the rings without the notch (it's not easy) and push it over the top end of the support tube to hold the top spring retainer in place.

Turntable & rotation pegs (shown at ¾ scale)

Use the full-sized turntable template provided at makeprojects.com/v/33. Peg specs are in red.



3a The turntable is just ¾" deep, but start with at least a 12" length of pipe for safe cutting on a power saw.

IMPORTANT Center-punch all hole locations before drilling.


3b


3c

3d

3. MAKE THE TREAT TURNTABLE

3a. Follow the diagram to make the turntable and rotation pegs. When cutting the ¾" wood and 3" PVC pipe, ensure that the cuts are straight, parallel, and square to the sides. The wood disk should fit tightly into the PVC ring. Glue it in place and sand both faces smooth.

3b. The positioning of the rotation pegs and the locations of the treat holes are critical. The red lines indicate peg locations; extend them onto the sides of the PVC pipe. Draw a line around the outside, centered between the 2 faces.

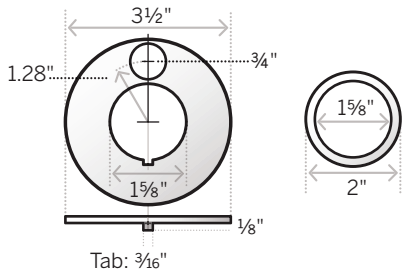
3c. Drill the center hole with a fly cutter bit. This hole should initially fit snugly over the support tube. Drill the 8 treat holes using a spade bit.

Make a drill press jig for the peg holes. Using a length of the 1¼" pipe (1⅝" OD) resting in a wood V-block, with the bit set to stop at a depth of ¼", drill the 8 peg holes.

3d. Cut eight ½" rotation pegs from ¼" acrylic dowel, ensuring the ends are square and smooth. Tap them lightly into the peg holes with a hammer and glue them in place. The ends of the pegs should just clear the ID of the 4" PVC drain pipe.

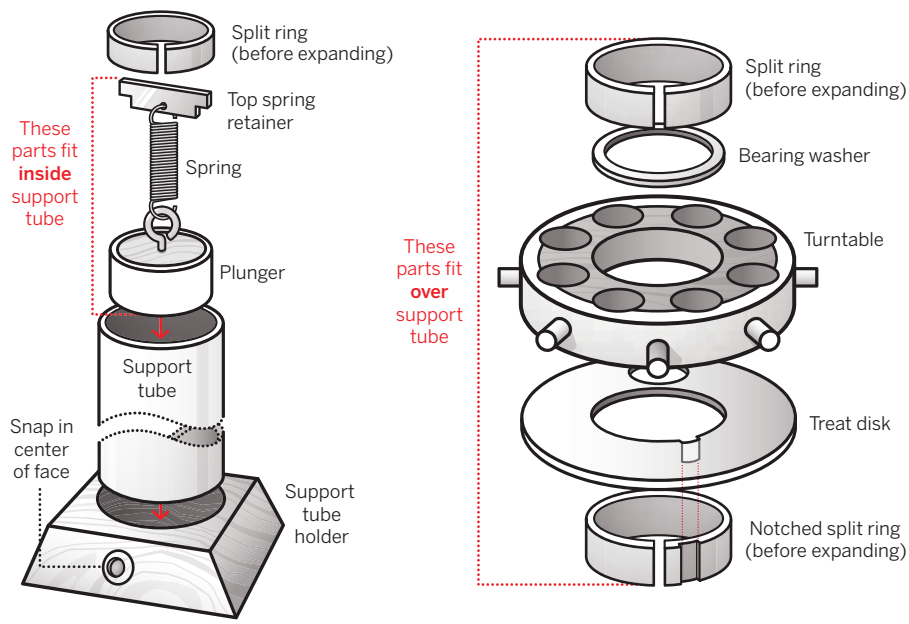
You can radius the ends slightly on a sander to help achieve a close fit.

3f **Treat disk & bearing washer**



4a

4



3e. After the turntable is completed, sand the large center hole so it rotates freely on the support tube.

3f. Cut the treat disk and bearing washer from 2mm HPDE plastic, following the diagram. (If you bought 90mm disks, they're almost exactly the size of the treat disk.) Lay out the 2 parts on the plastic and drill both large holes with the fly cutter bit. Use a ¾" spade bit for the smaller hole in the treat disk. Then cut out all the parts with shears.

Use side-cutting pliers to snip the tab on the inside diameter of the treat disk, and carefully bend it down 90°.

4. ASSEMBLE THE SUPPORT TUBE.

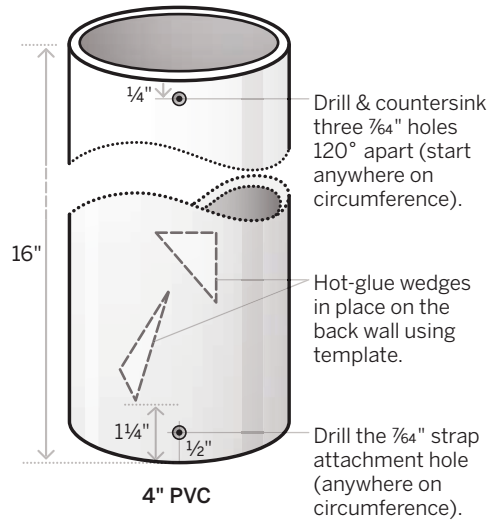
Following the assembly diagram, spread and slip the second notchless split ring onto the support tube from the bottom. Follow with the bearing washer, the turntable, and the treat disk.

4a. Press the notched split ring on last, so that the bent-down tab on the treat disk will be trapped by the notch to keep it from turning.

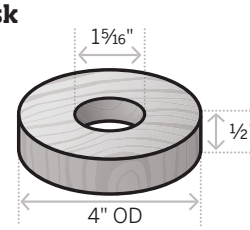
Position the bottom surface of the treat disk 5½" from the bottom of the support tube.

4b. Press the support tube assembly into its holder on the base without fastening it. Don't fasten the split rings either, to allow for adjustment.

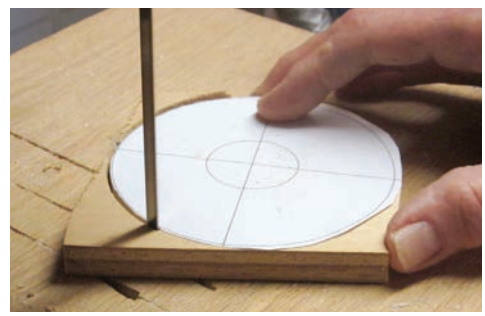
5a Scratch cylinder

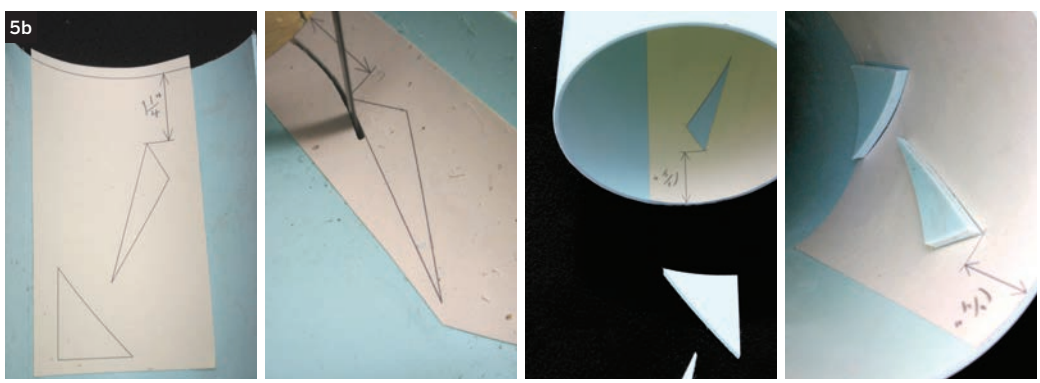


5c Top disk



Make from ½"-thick wood.





5. MAKE THE SCRATCH CYLINDER PARTS

5a. Cut the scratch cylinder, following the diagram.

5b. Cut the 2 sets of wedges using the full-sized template at makeprojects.com/v/33. These will rotate the turntable one-half position on the downward stroke of the scratch cylinder, and then one-half position on the upstroke, releasing the treat.

Split lengthwise an 8" piece of 4" PVC pipe. Temporarily spray-glue the template to the inside of one of the pieces, and cut 2 sets of wedges with a band saw. Super-glue the duplicate wedges together, doubling their thickness.

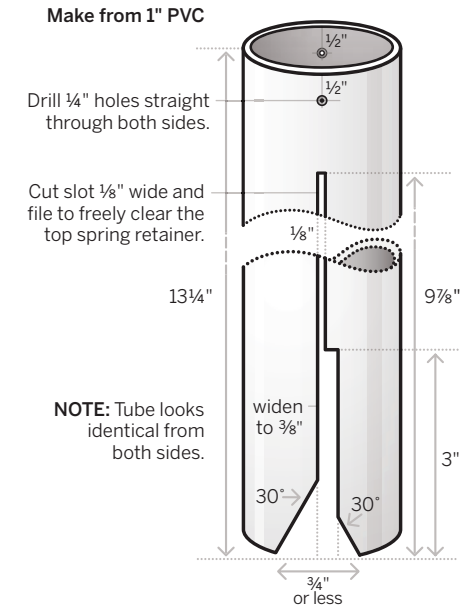
On another copy of the template, cut out the wedge holes. Temporarily spray-glue this template to the inside wall of the scratch cylinder 1¼" from the bottom end, anywhere on the circumference. Hot-glue the wedges in place, using the negative template to position them accurately.

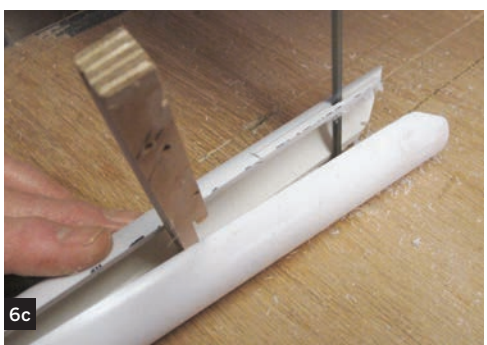
5c. Using a band saw, make the top disk and sand it to fit tightly into the top end of the scratch cylinder. Use the fly cutter bit (reset to just under 1 5⁄16") to drill its center hole.

Fasten the top disk to the cylinder using 3 small flat-head wood screws.

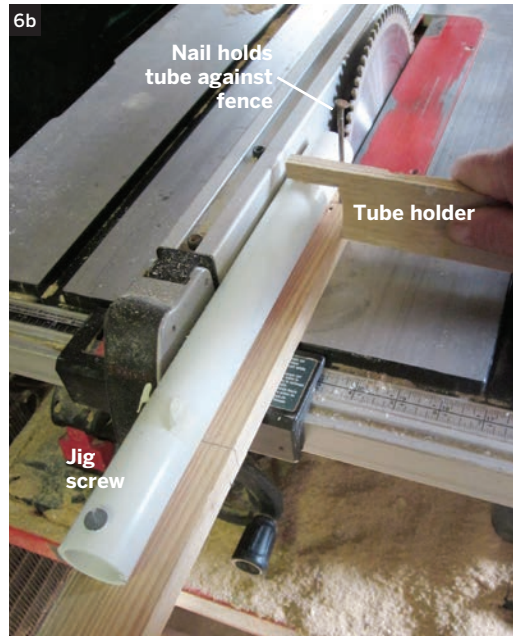
5d. Wrap the scratch cylinder with Berber carpet hot-glued in place.

6a **Inner tube**

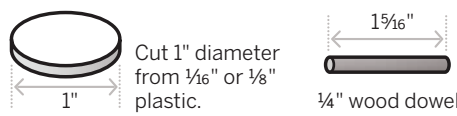




6b



7a **Catnip disk, and disk pin**



6. MAKE THE INNER TUBE

6a. Following the diagram, drill the ¼" holes in the 1" PVC pipe (1 5⁄16" OD). Then make a wood jig and screw the pipe to it through the holes.

6b. On a table saw, cut the top slot ⅛" wide. Allow for the radius of the blade and the thickness of the jig itself to determine where to stop cutting. Finish extending the top slot on a band saw to its full 9⅞" length.

6c. On both sides of the tube, widen 3" of the slot to ⅜" with a band saw as shown. Use a wood wedge to hold the slot apart for easier blade access. File the slot if necessary to make sure it clears the top spring retainer during the plunge stroke.

7. ASSEMBLE THE SCRATCH CYLINDER

7a. Follow the diagram above to make the catnip disk and disk pin.

7b. Insert the catnip disk pin through the end of the inner tube, and glue the catnip disk into place using the pin as a stop and gluing surface.

7c. Press and glue the inner tube into the cylinder top disk. It must be centered within the scratch cylinder.

8. TEST AND TROUBLESHOOT

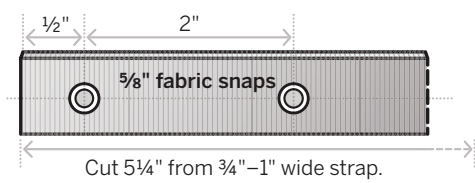
Load the turntable with treats, and drop the scratch cylinder assembly over the support tube assembly. The inner tube must slide easily into the support tube.

Pull down on the scratch cylinder to cycle your Scratch-a-Treat, testing for smooth operation and ensuring that treats are dispensed.

If you feel friction, there could be several sources:

- Between the slot in the inner tube and the top spring retainer. Try removing the scratch cylinder, turning it 180°, and replacing it. Or widen the slot slightly, especially at the top.
- Between the inner tube and support tube. Remember that the inner tube must be centered in the scratch cylinder.
- Between the turntable and support tube. Sand the center turntable hole as necessary.
- Between the rotation pegs and the wedges inside the scratch cylinder. Smooth these parts as necessary to reduce friction.

If treats aren't dispensed, adjust the height of the turntable on the support tube and/or turn the treat disk (and its split ring) so it releases all the treats reliably.



9 **Strap**

9. FINAL ASSEMBLY

Remove the scratch cylinder and fasten the 2 lower split rings to the support tube with short screws. These must not protrude inside the support tube.

Make the fabric strap per the strap diagram and screw it to the inside bottom wall of the scratch cylinder. Turn the support tube in its holder to align the snaps.

TEST BUILDER: Isabella Ghirann, MAKE Labs

Tame That Kitty

When you first set up your Scratch-a-Treat, use the strap's end snap to limit the spring's bounce when Kitty releases the scratch cylinder. Use the shorter snap position to disable the plunge action altogether when Kitty becomes accustomed to using Scratch-a-Treat as a proper scratching post.

You don't need to remove the scratch cylinder to load treats. Simply unsnap the strap, lift the scratch cylinder about 4", rotate it clockwise, and let go. Load the treats into the turntable, then reverse the process to drop the scratch cylinder back into scratching position.

A variety of treats can be used. We favor the crunchy, catnip-flavored Temptations brand.

Rubbing a bit of catnip onto the carpet will help attract your cat initially and encourage scratching.

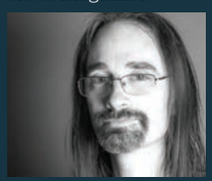
As with all pet training, praise Kitty generously when she uses the Scratch-a-Treat, and administer a stern scolding when she does not.

Grandma's knees will be happy.

Larry Cotton is a semi-retired power-tool designer and part-time community college math instructor. He loves music and musical instruments, computers, birds, electronics, furniture design, and his wife — not necessarily in that order.

Phil Bowie is a lifelong freelance magazine writer with three suspense novels in print. He's on the web at philbowie.com.

KEITH HAMMOND
is projects editor of *Make:* magazine.



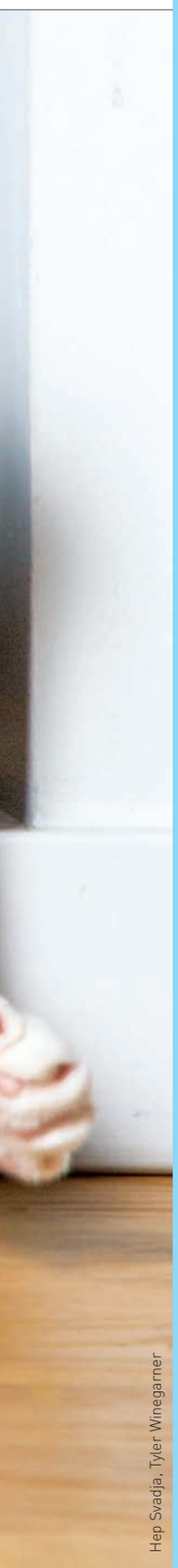
SAM BROWN
is driven by the need to create, travel, and learn new things. He has a history of making clever wooden things, board games, and circuits, and looks forward to doing stranger things yet.

Cat Activated Laser

Written by Keith Hammond and Sam Brown

This hyperintelligent toy uses furry face recognition to entertain your pet

Hep Svadja, Tyler Winegarner



Hep Svadja, Tyler Winegarner

Time Required: 3–8 Hours
Cost: $500–$600

MATERIALS

- **Nvidia Jetson TX1 Developer Kit** Includes the Nvidia Jetson TX1 development board, AC adapter and power cord, USB Micro-B cables (Standard-A and Female Standard-A), rubber feet (4), Quick Start Guide and Safety Booklet, and Wi-Fi antennas (2)
- **Arduino Uno microcontroller board**
- **Laser diode, 3V, 5mW** such as Amazon #B00VCR036Q. Or use a 5V laser diode and omit the transistor.
- **Transistor, NPN**
- **Hobby servomotors, micro size (2)** such as Amazon #B00ZEDRR3Q
- **Mounting brackets, for pan-tilt setup** You can fabricate your own from wood, plastic, or metal; buy a pan-tilt bracket; or find one at Thingiverse to 3D print.
- **USB thumb drives, 32GB (2)**
- **Mini breadboard** such as Jameco #2155452
- **Jumper wires**
- **Enclosures (optional)** for Jetson TX1 and Arduino. We made our own from acrylic; you can download our files and cut and bend them yourself (see HARDWARE Step 2).

TOOLS

- **Computer** with an x86 processor — i.e., a common desktop or laptop computer, not a Raspberry PI or other computer with an unusual chip at its heart
- **Arduino IDE software** free download from arduino.cc/downloads

THIS CAT-TEASING LASER POINTER ACTUALLY RECOGNIZES CATS and only activates when a cat is present — not a person, only a cat!

The cat spotter is built around the Nvidia Jetson, a processor built for neural networks and other AI tasks. It's doing actual visual processing to distinguish cats from all those lesser, non-cat things in the world. Our Jetson loads a neural network that was trained on flashcard-like images until it learned to distinguish felines and other fuzz-balls from reality's more boring, non-furry occupants.

Here's how to build your own neural-network Cat Spotter.

INSTALL THE SOFTWARE

To jump-start you into this project, we've prepared a complete software install on the Jetson, with the Cat Spotter running from the moment it turns on.

The software that updates the Jetson only runs on Ubuntu Linux, so we'll start by making a flash drive that lets any computer boot up as an Ubuntu computer. We used the utility UNetbootin to make this bootable USB stick.

We'll also need the hard drive image that we're going to clone onto a second flash drive — download it from the project page online at makezine.com/projects/jetson-tx1-cat-spotter-laser-teaser.

Both of these downloads,Ubuntu for UNetbootin and the Jetson drive image, are many gigs large, and will take a while to download. Let's construct the Arduino laser controller while we wait.

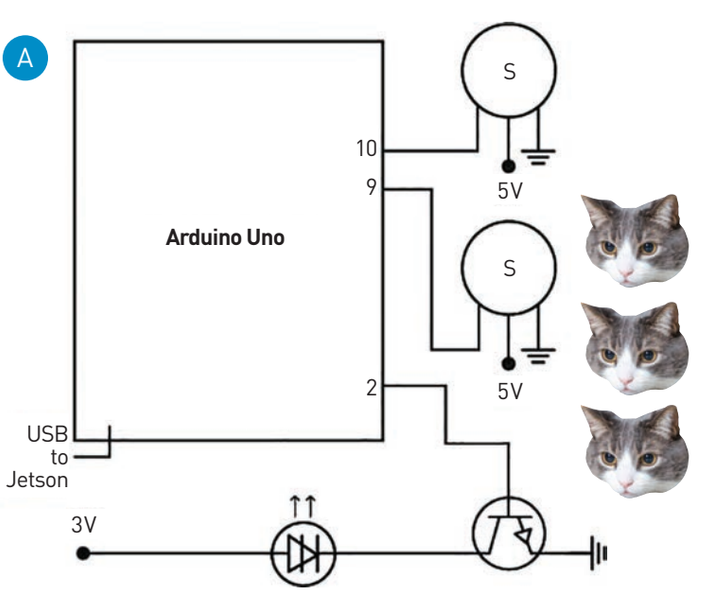
CONNECT THE HARDWARE

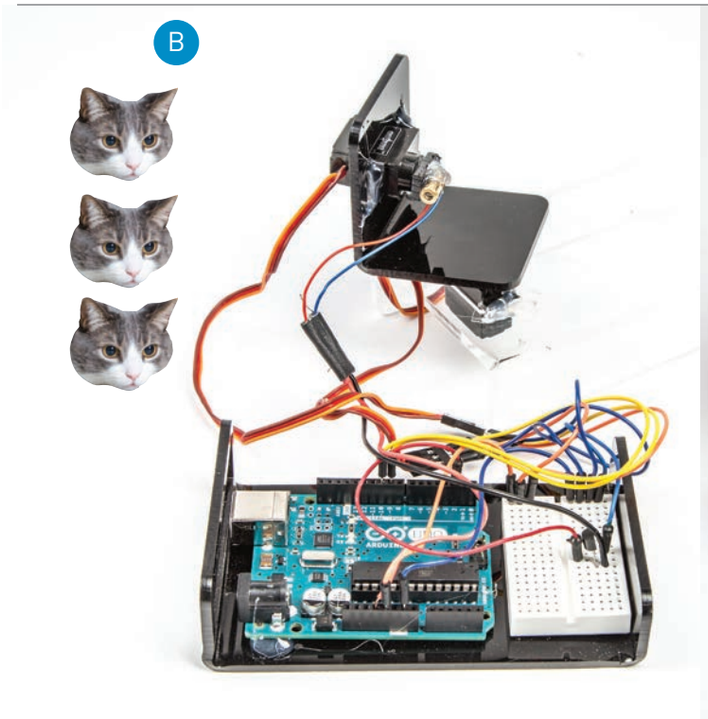
The hardware is simple: a bare laser diode you can buy cheap online, two standard mini servos mounted in pan-tilt brackets, and an Arduino microcontroller to control them. Finally, we add an NPN transistor to let the Arduino switch the 3.3V power on and off.

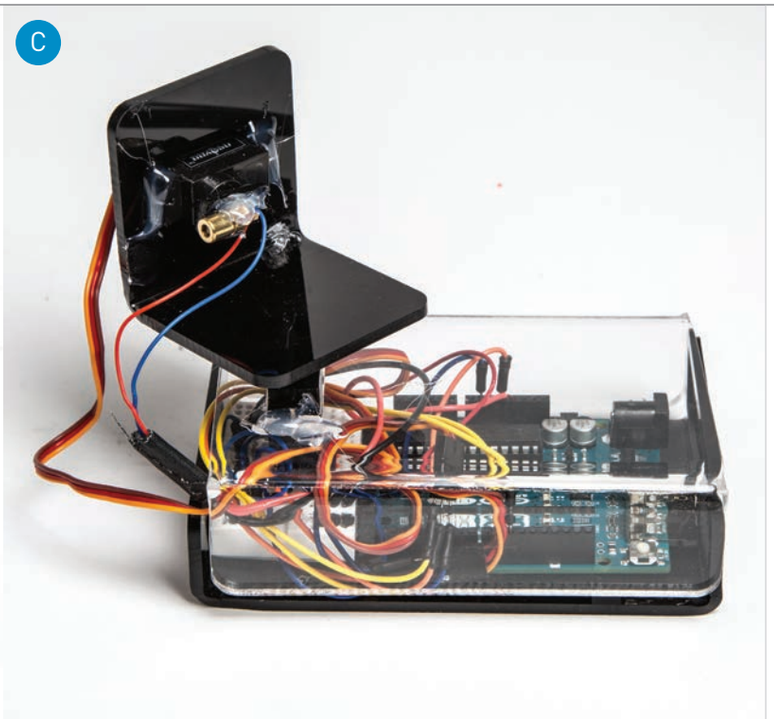
1. To build a simple pan-tilt laser cat teaser, connect the two servos and the laser diode to the Arduino as shown in the wiring diagram in Figure A. The laser is connected to the +3.3V pin; the servos are connected to the 5V pin.

2. Mount the servos to a 90° bracket and

A







to the top of your Arduino enclosure, as shown in Figure B. Then mount the laser to the bracket as well, pointing straight ahead level. After you've gotten the system working, you'll want to tilt the laser to the floor or another surface your cats can reach.

By visiting makezine.com/projects/jetson-tx1-cat-spotter-laser-teaser you can download our Illustrator files to cut the bracket and Arduino enclosure from acrylic (Figure C) or metal and bend them yourself, or download a pan-tilt mount for 3D printing from Thingiverse, or improvise your own solution.

You can also download our Jetson enclosure files for acrylic or metal. (We cut these files from flat acrylic, then used a strip heater to put the bends in them. Note that the PDF files for the enclosure have increased line weights. Many models of laser cutters decide how to cut a line based on its weight, so you may need to change these before cutting.)

Your New Neural Network

Your new cat toy recognizes felines using a *neural network* — software that learns from experience, similar to the way the brain does. And the Jetson TX1 can run a new image through that network in milliseconds rather than seconds. Superfast image recognition opens up new options for robots that need to keep up with the real world and dodge obstacles.

There's quite a bit going on behind the scenes to make your Cat Spotter run, and all these parts are now installed and ready for you to explore on your Jetson:

Caffe (caffe.berkeleyvision.org) — the neural net we're using to recognize felines is one of the examples included with Caffe, a package for building new neural nets. It's particularly good for visual recognition.

Digits (youtube.com/watch?v=jUiudfxjdr8) — another way to set up and explore neural nets, no coding required.

CUDA (developer.nvidia.com/cuda-education-training) — unlocks the power of the Jetson to run many, many tasks simultaneously, such as ...

cuDNN (developer.nvidia.com/cudnn) — the software that taps into CUDA to run neural networks with exceptional speed.

3. Download the Arduino sketch from github.com/baudot/cat_play_jetson_triggered. Open it in the Arduino IDE on your computer and then upload it to your Arduino board.

4. Connect the Arduino to the Jetson via USB.

Your laser teaser hardware is complete. Now you just need to program your Jetson to be a Cat Spotter: to recognize cats and initiate the laser teaser whenever it finds a feline.

SET UP THE CAT-SPOTTING SOFTWARE

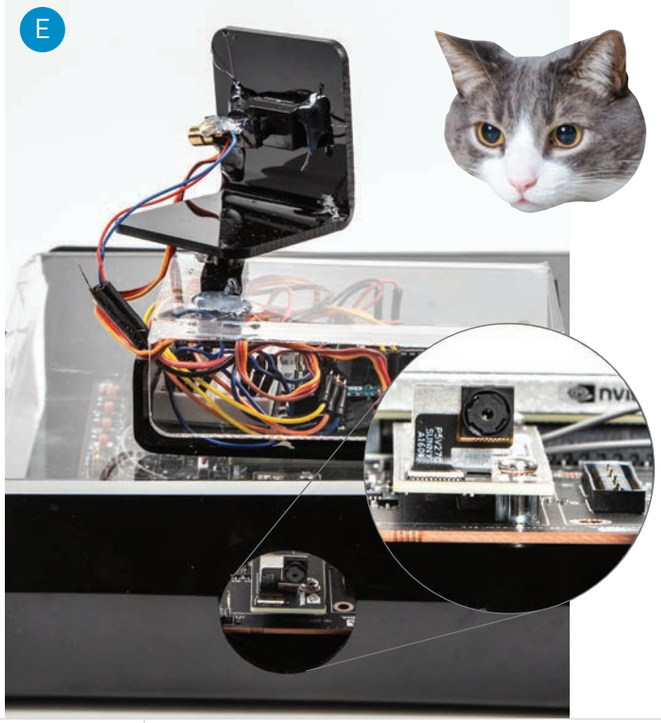
1. To get the Jetson ready to recognize cats, you'll use a pre-made neural network that's already been trained. We've included this program in the drive image you started downloading before working on the laser.

2. Partition the second USB thumb drive with the ExFAT file system. Most USB sticks use the older FAT file system, which won't accept files over 4GB, such as our 10GB image download.

3. Copy the downloaded file (*laser_cat.tgz*) to the second thumb drive.

4. Reboot your computer with the first

Hep Svadja



thumb drive, the one prepped with UNetbootin, to launch Ubuntu Linux on your computer. The NVIDIA software tool, JetPack, is written for Ubuntu Linux.

5. Add support for ExFAT drives to that Ubuntu system by opening a terminal window and entering these three commands, in order:

```
sudo add-apt-repository universe
sudo apt-get update
sudo apt-get install exfat-utils
exfat-fuse
```

6. Plug the second flash drive into the Ubuntu computer, which should now recognize it.

7. Copy the *laser_cat.tgz* file to the Ubuntu system. This copy could take several minutes.

8. Open a terminal, and `cd` to the directory where you dropped the copy of *laser_cat.tgz*. Unzip the file with the command:

```
tar -xvzf laser_cat.tgz
```

This unzip could take several minutes.

9. After the file has been unzipped and untarred, run the command:

```
cd bootloader
```

to enter the freshly unzipped directory.

10. Attach the Jetson to your computer running Ubuntu, using the USB to micro-USB adapter cable, with its micro-USB side plugged into the back of the Jetson.

11. Power down your Jetson. Power it back up, immediately holding down the Update button after releasing the power button. While continuing to hold down the Update button, briefly tap the Reset button, wait 2 full seconds, and then release the Update button.

The Power button is the far right button, if the buttons are turned to the front of the Jetson (with the Wi-Fi antenna at the back). The Update button is second from the right. The Reset button is furthest left (Figure D).

12. Confirm that your computer running Ubuntu can see the Jetson attached to it, by running the `lsusb` command in a terminal window. If you see "NVIDIA" in the list that appears, you've confirmed that your computer can connect to the Jetson to update it.

13. You're still in the *bootloader* directory on your Ubuntu machine? Good. Now load our pre-made laser-cat software from the Ubuntu computer onto the Jetson by typing:

```
sudo ./tegraflash.py --bl cboot.
bin --applet nvtboot_recovery.
bin --chip 0x21 --cmd "write
APP laser_cat_APP.img"
```

Allow this command to run to completion (about 15–20 minutes) and then you're done. You've copied over a complete clone of our working Jetson system, which has the pre-trained neural network.

Disconnect your laptop from the Jetson, and reboot the Jetson. Make sure its camera has a clear view through the enclosure (Figure E). It should immediately start looking for cats!

Getting a Glimpse

For debugging, you can see what your Cat Spotter sees by launching the `imagenet-camera` program from a terminal window on the Jetson. The program lives at *~/Desktop/workspace/cat-spotter/build/aarch64/bin/imagenet-camera*. You'll need to `cd` to its actual directory to run it. When you run the program in user mode, it brings up a video window showing what it sees, and whether it's recognizing a cat at that instant or not. You'll also likely want to tilt your pan-tilt unit so that it always points the laser at the floor, or modify the Arduino code to achieve the same effect.

To see the Cat Spotter in action, visit makezine.com/projects/jetson-tx1-cat-spotter-laser-teaser.