BUILD A WORKING STAR WARS-INSPIRED BB-8

LEARN THESE SKILLS

- Spray Paint Techniques
- Choose the Right Battery
- Work with Sheet Metal
- Know Your Rivets

40 PROJECTS

+ 3D PRINTED R/C RACE CAR
+ MILLION COLOR FLASHLIGHT
+ WATER BALLOON CANNON

+11 TOOL REVIEWS

Check Out Our Favorite Infrared Thermometer
CONTENTS

COLUMNS
Reader Input 06
Welcome 08
Reinventing the first text message system.
Made on Earth 10
Explore the amazing world of backyard technology.

FEATURES
Space Chase 18
The founders of Carbon Origins moved to the desert to build and launch rockets. Not so easy.
Maker Pro Q&A 26
Sugar inventor Jane Ní Dhulchaoíntigh talks about finding her product’s niche.

ON THE COVER:
Roll over, R2-D2 — BB-8 is the new droid everyone wants to build. Photo: Hep Svadja

18
Mad Hacks 28
Your wheels are your identity, so car or bike, mod them to your satisfaction!
World’s Cutest Go-Kart 30
Designing and building the electric Chibi-Mikuvan for the Power Racing Series.
Making the Switch 34
Build the Switch electric vehicle — a street-legal, Maker-ready kit and education system.
Evolutionary EVs 35
These DIY car makers are pushing past the electric-vehicle big boys.
Own Your Car 36
Will a vague copyright law constrain what hobbyists and modders can do with their vehicles?

30
Maker’s Dashboard 40
Why settle for a factory dash? Customize your cockpit with these projects.
Bike Hacks 41
Personalize your ride with these clever pedal projects.
Electro-fy Your Bicycle 42
Finally, an e-bike conversion that anyone can do.
Bottle-Cap Bike Light 46
Upcycle soda bottles to make this long-lasting, waterproof, automatic flasher.
Inside the Monowheel 47
Tips on fabricating this fun and unique rolling-hoop ride.
Cycle Chaser Bike Projector 48
Shine fun animations on the street that move depending on your speed!
SKILL BUILDER
Tips on Batteries, Rivets, Spray Paint, and More 49
Explore the tools and techniques you need to take on those challenging projects.

PROJECTS
Building Your Own
BB-8 58
Three takes on making your own homebrew ball droid.

Chukudu Wooden Scooter 62
Build the burly Congolese workhorse that can haul hundreds of pounds of cargo.

Million Color
HSL Flashlight 64
Bring fun back to the flashlight with Arduino and full-color NeoPixel LEDs.

3D-Print a Badass
R/C Race Car 68
Make this ripper with a motor, wireless microcontrollers, and a few bucks of filament.

Semi-Automatic Coffee Roaster 72
Three cordless screwdrivers and a microcontroller = perfect small-batch roasting.

1+2+3: Realistic Duct Tape Rose 73
Surprise your sweetheart with a handsome handmade flower.

Remaking History: Henry Bessemer and the Age of Steel 74
Learn how to heat-treat and toughen the metal that built our world: carbon steel.

Electronics Fun & Fundamentals: The Greenest Delay Timer 76
Wire up a clever timer circuit that draws no current between cycles. What could be greener?

Amateur Scientist: Night Tracking Rockets 78
Use LEDs to track night-launched projectiles.

Water Balloon Cannon 80
Build a simple PVC air cannon to help you win the water wars.

1+2+3: Custom Soda Cooler 81
Summer is hot. So why not make a custom cooler to keep your drinks cold?

Howtoons 82
Construct an easy homemade Pinewood Derby track.

Pixel Pals 84
Learn how to solder Chip and his Pixel Power base, then plug him into an Arduino.

Toy Inventor’s Notebook: Footstep Stamper 85
Hack a pair of flip-flops so they make designs in the sand as you walk.

OVER THE TOP
A Brief History of 21st Century BattleMecins 96
If you were a MechWarrior fan in the 90s, your dreams are about to come true.

TOOLBOX
Tool Reviews 86
Unique and useful Maker tools, toys, and materials.

New Maker Tech 88
On the horizon for electronics and accessories.

Books 90
Text tools for your bench or bedside table.

3D Printer Review 92
Printbot Metal Plus, thoroughly tested.
LOOK OUT, R2! Everyone’s favorite astromech is facing stiff competition from a new addition to the Star Wars universe named BB-8. Aside from being impossibly cute, BB-8 is a puzzle of engineering that features an R2-style head gliding on a rolling, spherical body. As a fan, it’s impossible not to want one. As a Maker, it’s impossible not to try to craft one. Want to get started? Here are 3 different approaches for building your own.

Pocket-Sized Roller:

**Time Required:**
1 Day

**Cost:**
$150-$200

**Materials**
- Sphero 1.0 robot toy
- Plasti Dip spray, GunMetal, Gray
- Spray paint: orange, white, and clear enamel
- Neodymium ring magnet, ¼”
- Neodymium disc magnet, ½”
- Felt pad, 030” x ⅜” diameter, adhesive-backed
- Polyurethane foam
- Wood spackle
- Masking tape
- Sharpie marker

**Tools**
- Hacksaw
- Bench vise
- 3D modeling software
- Glue gun
- Hobby knife
- CNC mill (optional)
- Laser cutter (optional)
- Drill press (optional)
POCKET-SIZED ROLLER

Written by Christian Poulson

PROJECT #1
Hack a Sphero to replicate the galaxy's adorable new droid

CHRISTIAN POULSEN
is a recent graduate from Brigham Young University with a degree in industrial design. In addition to his freelance design work, he enjoys restoring his '70s Porsche named Sebastian.

AS AN INDUSTRIAL DESIGNER, I’VE BEEN PARTICULARLY FASCINATED BY PRODUCTS THAT HAVE PERSONALITY AND EMOTION. I think the droids in Star Wars have always been really great at capturing a character without facial expression and drawing you in. And BB-8 was no different when they brought it out onstage for the first time at Star Wars Celebration.

As I watched it roll around, my only thought was, “Need!” So I made one.

Part of what I really enjoyed about the process of making it was the timeline. Most projects I work on end up taking weeks, if not months, to finish. With BB-8, I pushed myself to make it in a day. As a result, the surfacing and paint is less than perfect, which I’m serendipitously calling “weathered.” But I was able to stick to my goal, and made the whole thing in a matter of hours. I wanted to capture the character and personality of the real robot as simply as possible, and I’m really happy with how it turned out.

1. SPLIT SPHERO 1.0
Divide the Sphero toy along the seam using a hacksaw, being careful not to saw through the internal chassis. (I’ve never split open the Sphero 2.0, so I’m not sure if it will work on that model.)

2. EMBED THE MAGNET
The internal chassis of the Sphero has a post that pushes against the top of the sphere and acts as somewhat of a shock absorber — attach the ¾” neodymium magnet ring to this post. Clean the edges of the split sphere with a hobby knife and, with the newly magnetized structure inside, reattach the 2 halves with hot glue.

3. DESIGN AND FABRICATE THE HEAD
Create in your preferred 3D modeling program or simply carve by hand. I built it in Rhino over a screenshot from the trailer to make sure I had the proportions right. I milled out my design on a CNC using polyurethane foam, then used wood spackle to finish the surface.

4. MASK AND PAINT
Cut the designs out of tape to mask off the different colors. I went a little overboard and laser-cut mine, and used gray Plasti Dip for the base coat because it’s more opaque than regular spray paint and I wanted to block out the Sphero’s flashing LEDs (a glowing green droid just wouldn’t work for me). After the base coat is dry, cover with orange spray paint.

5. APPLY FINISHING COATS
Mask out the orange and add a coat of white paint. Add the details with a Sharpie and finish it with a final coat of clear enamel. The topcoat is particularly important to get just right, to reduce friction as much as possible between the head and body.

6. ADD MAGNETS AND FELT
Once the paint is completely dry, embed a ¾” neodymium disc magnet in the head. Add a small adhesive felt pad so that it can slide easily across the surface of the body. I used a drill press to sink the magnet in just deep enough to be flush with the surface and glued it in place before attaching the ¾”-diameter felt pad over it.

The droid is controlled by Bluetooth through the Sphero app, but also has a mind of its own. Because it’s now more top-heavy and tends to lean, the gyroscope will try to correct the lean, and it will keep on rolling in whatever direction it’s pushed. Maybe adding weight in the bottom will tame it, or maybe BB-8 needs a restraining bolt!

For a more detailed guide to making this project, visit makezine.com/go/sphero-bb8.
WHAT THE HECK WAS THAT?

This was my first impression of BB-8 when a 3-second glimpse of it was revealed during the first “teaser trailer” for *Star Wars* Episode 7. No one had seen a droid such as this. A dome bouncing along on a rotating ball.

I had to have one.

I reasoned that I could drive a ball with a remote control tank inside. The trick would be to keep the dome from falling off. Three weeks later, I had an outer shell with a finished Styrofoam dome. The dome had five cannibalized computer mice underneath, their rubber balls replaced with ¼” steel bearings. The inner tank had a framework attached, supporting an array of five magnet columns, spring-loaded to keep them in contact with the inner ball while the tank crawled around the interior. This design failed for two reasons. Firstly, the tank only touched the ball on its four corners, so there was little traction. Secondly, the inertia of the droid when it stopped kept the lower ball rolling, causing the upper dome to tip off. I needed to increase the traction and come up with a way to stabilize the ball.

The solution I came up with was a custom drive system that puts the weight and traction directly in the bottom of the lower ball. Two rubber drive wheels, powered by two Power Wheels motors and gearboxes, and controlled by radio with a Sabertooth 2×25 motor controller, would give me the control and traction I needed. I would be able to turn the drive system 360° and have enough power to overcome the drag of the magnets at the top of the ball. I added a sliding platform so that I could move the magnet array forward and backward inside the lower ball. A 360° servo rotates the magnet platform and the upper dome.

For the enclosure I used 18” polycarbonate globes from edee.com. [The community now feels 20” is more accurate.] I used the globes come with a hole already cut out, and gaps occur when you cut out the outer shell pieces, three globes are needed.

To stabilize the droid, I purchased the only “old school” gyroscope I could find, but it didn’t have enough rotating mass to stabilize such a large ball. To add more rotating mass, I built four additional gyroscopes out of discarded computer hard drives, stacking four discs in each drive and spinning them with a control circuit, powered by a battery.

I also tried to replicate the different emblems on the sides of the body. And now that we have better pictures of BB-8, I plan to rework the outer shell to make it even more movie-accurate.

To see the full, finished build of Zimmerman’s BB-8, visit makezine.com/go/zimmerman-bb8.
WHEN THE STAR WARS: THE FORCE AWAKENS TRAILER WAS RELEASED, THE INTERNET WAS BUZZING ABOUT THIS NEW ROUND DROID.
With a renewed interest in practical effects, our curiosity was piqued. “Are they going to actually make one?” This question was answered at the Star Wars Celebration. Our curiosity became an obsession as we watched BB-8 roll around and size up R2-D2. The ball droid was real, and hackers and Makers around the world thought they had the answer as to how it worked. Concept art, 3D prints, and prototypes started popping up on YouTube and we knew we had to throw our hat into the ring.

Since there are others trying to crack the BB-8 we wanted to work quickly on our proposed solution. With the help of ServoCity and their online CAD models, we quickly leveraged the Actobotics line to build the inner structure. For some of the detail pieces and internal components, we turned to 3D printing to give us quick results. The Loveland CreatorSpace provided us a base camp and excellent resources to complete this build.

The inspiration for our mechanical build was the Sphero. We had a hunch when the first videos were released that Sphero was involved somehow. We popped one open and began to replicate the mechanism. To add the head and motion we took cues from an older Sphero model. The original Sphero has a singular upper support, whereas Sphero 2.0 has two passive upper wheels to maintain support. Our design combines aspects of both, using upper wheels for stability and a central support to attach the head via magnets.

The shell is 2 custom-molded ¾”-thick polycarbonate hemispheres. We decided to go this route to ensure roundness, strength, and enough thickness to mount LEDs in the moving shell.

The team behind our build consists of four Makers with a shared passion for robotics and Star Wars alike, and their obligatory dog companion. I was responsible for the mechanism that brings the BB-8 to life. Pamela Cortez, another SparkFun engineer, developed the brains of the droid, which consist of Raspberry Pi and Sphero. She also focused on giving our BB-8 a voice, which includes some Easter egg sounds from your other favorite droids! The aesthetics of the robot, including the floating head and movie-worthy details, were applied by Allison Cavis and Maurice Woods, two artists-turned-engineers whose sculpting and casting experience make the droid’s appearance unmistakable.

This BB-8 design is fully documented and open source! For the complete build, visit makezine.com/go/open-bb8.

Written by Casey Kuhns

PI-POWERED SUPER-SPHERO
A team of engineers and artists methodically creates a BB-8 that looks, moves, and sounds like the real thing

The team (from the left) includes Pamela Cortez, Allison Cavis, Casey Kuhns, Maurice Woods, and Felipe.

An inner structure was first carefully designed in software, based on the construction of a Sphero toy.

CASEY KUHNS
is a SparkFun engineer by day, and a gearhead by night. From Boulder, Colorado, he has built space payloads, restored a jet engine, and fought combat robots.
TheStarWarsTrilogy.com has the best magazine articles, interviews, photos and videos - old and new - from around the world, and it's all FREE! If you have enjoyed this publication, please visit www.TheStarWarsTrilogy.com to find many more.