GYROCAR

By Matthew Gryczan

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BALANCING ACT

Outfit a toy gyroscope with an electric motor to make it run continuously, and add an adjustable drive wheel that lets it chug along a monorail, balance on a string, circle the rim of a pot, and perform other tricks.

Anyone who's played with a gyroscope toy powered by pulling a string wound around its axle knows that it's fascinating, but also frustrating because it runs down so quickly and has to be rewound. I decided to make an electric version that runs for as long as its AAA batteries hold out — which can be at least a half-hour, since the spinning gyroscope wheel stores some energy, easing the load on the motor.

I went through 3 iterations before arriving at this simple design, which is easy to build and works well. In addition to battery power, the Gyrocar has a small track wheel at the bottom that's friction-powered by the main gyroscope wheel. The track wheel drives the Gyrocar along any thin, horizontal edge while it bears the gyroscope's weight, but otherwise it doesn't press against the main wheel, to avoid draining energy. Three screws let you adjust the track wheel or disable it entirely so that the Gyrocar stays idling in one place.

I'm sure MAKE readers will improve on my design. And if you've got access to a metal lathe, you can make an original version that isn't based on the toy.

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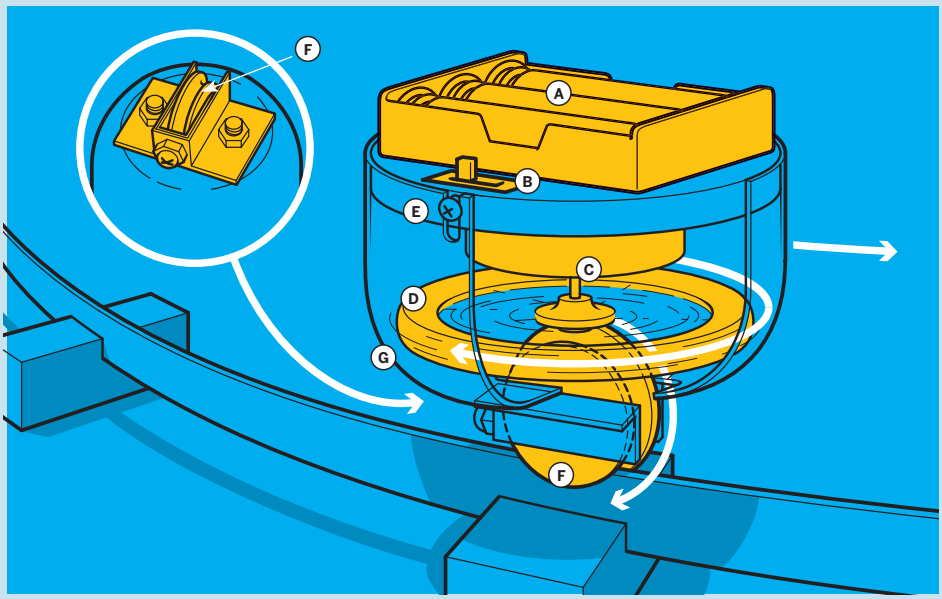
Matthew Gryczan is a former manufacturing engineer and newspaper reporter, and a lifelong basement tinkerer. In his day job, he writes news releases for science and technology companies at SciTech Communications.

Photograph by Sam Murphy

Staying Up

When a gyroscope (or top) isn't spinning, gravity just pulls down one side and it falls. But when it spins fast, gravity's force on that side is quickly rotated to other positions before the gyro has a chance to fall. As a result, the gyro self-corrects, with its axle tending back toward a right angle to gravity.



(A) Three AAA **batteries** power the Gyrocar's motor for 30+ total minutes.

(B) The plywood **motor mount** holds the batteries on top and the motor underneath.

(C) The motor's **axle** points downward and attaches inline directly to the gyroscope axle.

(D) The **gyroscope wheel** hangs down and rotates horizontally, creating gyroscopic forces. There's no axle underneath.

(E) **Three screws** let you adjust the plastic cap's position to precisely engage (or disengage) the gyroscope wheel with the drive wheel.

(F) The **drive wheel** turns vertically, centered underneath the gyroscope wheel. It's shaped like a biased pulley, and its larger side is friction-driven by the gyroscope wheel close to the center.

(G) A **plastic cap** attaches the motor mount to the bracket that holds the drive wheel, enclosing the gyroscope. The cap's thin plastic material flexes under the weight of the gyroscope, so that the gyroscope only engages with the drive wheel when the drive wheel bears the Gyrocar's weight.

THE KASHMIR LIMITED: BRENNAN'S GYRO MONORAIL

Our Gyrocar was inspired by the work of Louis Brennan, the inventor who made a fortune by creating the first guided torpedo for the British Royal Navy in the 1870s. Brennan spent the rest of his life trying to commercialize monorail systems that used huge gyroscopes for balance. He even built a 24-ton gyro locomotive for the British War Office and the Maharaja of Kashmir. But his ideas never caught on — neat factor aside, it's not practical to devote so much weight and energy to gyroscopes when you can simply balance on 2 rails.

Illustration by James Provost; photography by Getty Images

SET UP.

MATERIALS

[A] Scrap of 3/16" plywood or similar; 6"×6" is plenty

[B] Toy windup-style gyroscope or small metal wheel that can act as a gyroscope

[C] Small DC electric motor, 4.5V or 5V
I scrounged mine from an old CD drive, but any standard small motor should do. Solder wire leads to its terminals if it doesn't have them.

[D] 3xAAA battery holder shown here on the plywood motor mount. RadioShack part #270-412, $2

[E] Round plastic cap or container big enough to enclose the gyro wheel. Use a sealable storage container or the cap from a spray can or detergent. Cap sides should be straight, not tapered.

[F] Tension roller, 1" diameter × ¼" width for a sliding door, concave, steel, from a hardware store, or part #111731 from Slide-Co (slide-co.com), $8

[G] Sheet steel or brass, 22 gauge, at least 2"×3" from a hardware store. I bought a 6"×24" sheet for $9 that will come in handy for other projects as well.

[H] #6-32 machine screws, 3/8", with matching nuts and flat washers (2) or similar

[I] #10-32 machine screw, 3/8", with matching nut

[NOT SHOWN]

Small switch (optional) convenient for turning the Gyrocar on and off. I scrounged one from a toy.

Small plastic rod (optional) the same diameter as the gyroscope's axle, or slightly thicker. Use this if you're able to tap the toy gyro's axle out with a hammer (in which case you're lucky).

Small wood screws (5) for mounting the battery holder and plastic cap to plywood.

Wood glue

TOOLS

[J] Electric drill and drill bits

[K] Metal files or grinding wheel

[L] Hobby knife

[M] Tinsnips

[N] Pliers

[O] 10-32 NF (National Fine standard) tap

[P] Caliper or micrometer (optional)

[Q] Router or saw for cutting circles out of thin plywood. You could use a jigsaw, saber saw, band saw, or a hole saw mounted in a drill.

[NOT SHOWN]

Hammer

Sandpaper or rotary tool with sanding drum

Pencil and ruler

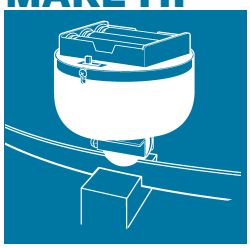
Try square and metal center punch (optional)

Glue gun and hot glue (optional)

Lathe (optional)

Photograph by Ed Troxell

MAKE IT.



BUILD YOUR GYROCAR

START **Time:** A Day **Complexity:** Easy

1. MAKE THE MOTOR ASSEMBLY

1a. Trace around the plastic cap on the plywood sheet. Use a saw or router to cut out a disk that size, then file and sand it down until it fits flush just inside the cap.

TIP: If you use a hole saw, back the plywood with another piece of wood. This ensures that the saw won't rip the grain on the exit side, so the disk will have clean edges. A hole saw also drills a hole in the center, which is fine.

1b. Measure the diameter of the motor, then scribe, cut, and sand 2 plywood rings whose inner diameters are just smaller than the motor and whose outer diameters are about twice the motor's diameter. File or sand the holes until the motor fits snugly inside. You can also cut a matching hole in the larger disk, which will give the gyroscope wheel more vertical space to fit inside the cap.

1c. The battery pack attaches flat on top of the large disk, so you need to make a way for the wires to run through the disk to the motor underneath. If you cut a motor-sized hole, use a small file or hobby knife to make a small channel deep enough to accommodate the wires under the battery pack. Otherwise, drill small holes that the wires can pass through, as shown here.

Photography by Ed Troxell

1d. Drill 3 roughly equidistant pilot holes into the circumference of the large disk, and temporarily insert 3 small wood screws.

1e. Glue the 2 small rings together on the bottom of the large disk, with all their centers aligned so that the motor fits in vertically.

1f. Test-fit the motor into the disk assembly and route the leads out the top. Use the remaining 2 small wood screws to attach the battery holder centered to the top of the large disk.

2. CONNECT THE GYRO WHEEL AND MOTOR

Now we'll attach the gyroscope wheel to the motor shaft. Getting this connection precise and strong is the most important part of the build, and you may want to use some ingenuity based on what your gyro wheel and motor are like.

2a. Remove the gyroscope wheel from its wire housing and try tapping the axle out with a hammer. If it comes free, you can fit in a plastic rod, which will make things easier. If the rod is a bit too wide to press-fit through the hole, chuck it in an electric drill and turn its diameter down by running it against a file.

If you can't extract the axle, saw it off and file or grind it down on both sides of the wheel.

2b. Use a caliper or micrometer to measure the diameter of the motor shaft. Find a drill bit that's the same size, or a few thousandths of an inch smaller if you've fit in a plastic rod. I used a #55 drill bit. The center hole you'll drill in the wheel must grip the shaft tightly, so that it doesn't detach at high speeds.

2c. As best you can, find the exact center point of the gyroscope wheel. (If you have access to a lathe, you can chuck the wheel on its outer diameter and drill a center hole on the lathe, skipping to Step 2e.)

If you inserted a plastic rod, push a pin into it where you think the center should be, then hold the pin pointing upward and gently spin the wheel like a top to see if it wobbles. Keep adjusting the pinpoint location and spinning the wheel, using trial and error until you find a good balancing point.

If you filed down the original metal axle, you can scribe crosshairs with a try square set to 45°, mark the point with a hammer and center punch, and test-spin the wheel with the pin in the mark.

NOTE: If you have a metal lathe, you might even try making your own gyroscope wheel.

2d. After you've found the center point, drill the hole for the motor shaft precisely at that point, as perpendicular to the wheel as possible.

2e. Press or tap the wheel onto the motor, as close as possible without interfering with it turning freely. This connection needs to be tight and strong. You can reinforce it with hot glue.

3. MOUNT THE TRACK WHEEL

3a. Download the track wheel mounting bracket template at makezine.com/23/gyrocar and print it at full size. Cut and trace the outline onto sheet metal, then cut it out with tinsnips and bend it with pliers, following the notes on the template.

3b. Drill the holes in the mounting bracket, as noted on the template.

3c. Use a file or grinding wheel to remove the head of the rivet that connects the tension roller to its spring steel leg. This will leave you with a free-turning wheel held by a small metal bracket; this is the drive wheel, or track wheel.

File or grind down one edge of the track wheel to reduce its diameter all around. The track wheel will be centered underneath the gyro wheel, but you want only one of its circular edges to touch the gyro wheel.

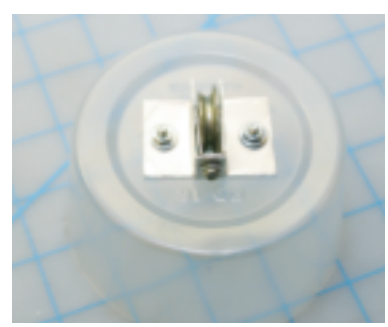
3d. Thread the existing hole in the wheel bracket with the 10-32 NF tap, and attach it with a #10-32 machine screw and nut to the mounting bracket you made. The screw should be about ⅜" long; it mustn't interfere with the free turning of the track wheel.

3e. Fit the motor into the plywood rings and route the wires back through as you did in Step 1f.

3f. The depth of the plastic cap from rim to inside bottom should be about ¼" greater than the height of the motor assembly from the top of the large disk to the bottom of the gyroscope wheel. If the cap is too deep, mark and trim its rim down evenly.

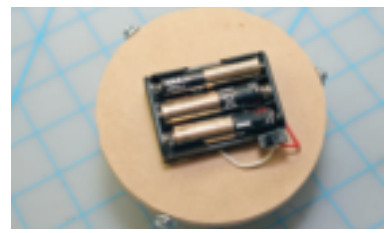
3g. Turn the cap over and mark a 5⁄16"×⅞" rectangle centered on the cap, plus 2 points 5⁄16" from the long sides, matching the bracket mount holes. Cut out the rectangle and drill the holes with a ⅛" bit.

3h. Secure the bracket and drive wheel to the bottom of the cap using two 6-32×⅜" machine screws, washers, and nuts.



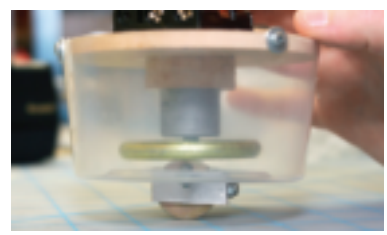
4. ASSEMBLE AND ADJUST

4a. To simplify construction, you can trim and connect both motor wires to the battery pack directly. This way, you turn the car on and off by popping one of the batteries in or out. But to make my latest Gyrocar easier to operate, I wired a small switch into one connection.

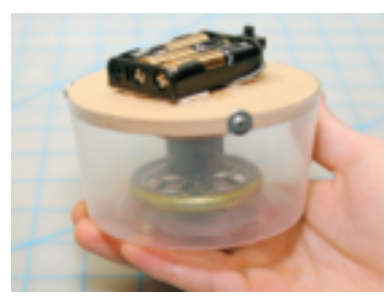


4b. In the rim of the plastic cap, cut 3 slots about ¼" long each, sized and spaced to accommodate the 3 screws on the circumference of the large disk.

4c. Now put the Gyrocar together by fitting the cap over the 3 screws on the disk. Run the motor and fix the cap's position so that the gyroscope doesn't press against the track wheel constantly, but only when the Gyrocar is resting on the track wheel and the thin plastic cap flexes slightly under the gyroscope's weight.



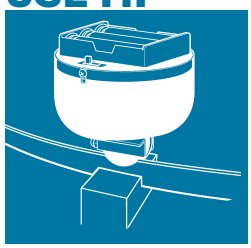
4d. Finally, adjust the screws that hold the drive wheel bracket to the cap so that the Gyrocar remains upright as it runs, rather than leaning to one side. You want to center the Gyrocar's center of gravity, and the holes in the bracket are large enough for some adjustment room. That's it; you're done! After these 2 adjustments are made, you won't have to make them again.



FINISH X

NOW GO USE IT »

USE IT.



TAKE GYROCAR FOR A SPIN

HIGH-WIRE ACTS

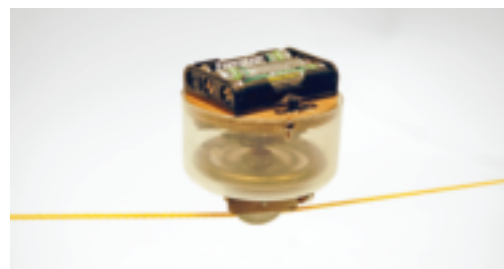
You can use a large cooking pot as a simple track for your Gyrocar, or you can make a track that offers more interest. I used an old band saw blade ½" wide by 64½" long that worked very well as a track for my Gyrocar.

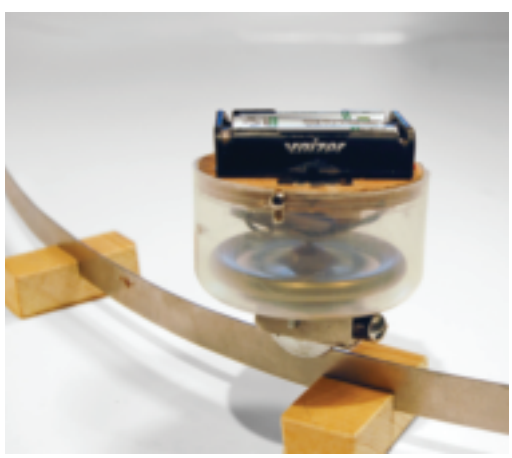
To hold the blade upright, I cut some 1"-wide blocks of wood out of standard 2" wooden furring strip and cut a ¼" deep slot in each with a thin saw blade. You can watch videos of the Gyrocar running on this track at makezine.com/23/gyrocar.

If you adjust the Gyrocar so that its track wheel doesn't turn, it will rest comfortably on a taut string — even travel along the string if it's raised or lowered.

I've built a few Gyrocars with different designs. For one of them, I used foamcore board instead of plywood, which I covered with colored foil wrapping paper. I also covered the battery pack with a hemispherical spray-can lid, all of which gave the Gyrocar a flying-saucer look.

For Gyrocar templates and videos of the Gyrocar in action, visit makezine.com/23/gyrocar.





Photography by Matthew Gryczan