Roomba® robot vacuum cleaners

by Chris Woodford. Last updated: November 29, 2016.

We're learning to love our machines—or, at least, that's how it's starting to seem! Things have come an awfully long way since the early 19th-century, when an infamous band of textile workers called the Luddites smashed up the machines they feared were stealing their jobs. What would they make of life 200 years later, when most products come from highly automated factories and many of us are now inviting robots into our homes? It's still very early days for household robots, but a popular little machine called the Roomba could be the shape of things to come. It's a small, computerized cleaner that nips round your house automatically brushing and vacuuming the carpets, rugs, and floors. How does it work? Is it any good? Should you buy one? Let's take a closer look!

Photo: When Roomba finishes the housework, it docks itself in this recharging station and charges up its batteries, ready for next time. The CLEAN button flashes orange while it's charging; once Roomba is fully charged, the button turns green, as shown here. The whole thing is extremely simple to use. You simply press the CLEAN button to start it off—and that's all you have to do. If you want it to clean while you're out, you can program in a complete daily or weekly cleaning schedule. This is one of the popular Roomba 560s dating

from around 2010.

What is Roomba?

Roomba is a compact, computerized vacuum cleaner that automatically guides itself around your home. Like a conventional cleaner, it picks up dirt with spinning brushes and a vacuum. There's a side-mounted, flailing brush that pushes dirt underneath the machine and, once there, two more counter-rotating brushes (turning in opposite directions) pick up the dirt and direct it toward the powerful vacuum, which sucks it away into a little storage bin. Unlike a normal cleaner, Roomba moves itself around your room with two large tractor-style wheels, each one independently driven by a separate electric motor. The wheels can turn in opposite directions, which means Roomba can literally "spin on a dime" and clean almost any space it can drive into. Power comes from an onboard NiMH rechargeable battery pack. That might be a drawback, but virtually all of Roomba's features have been designed to use as little power as possible so it can work for quite a long time (maybe 90 minutes if you're lucky) between charges. Roomba has numerous onboard sensors to detect dirt, dodge obstacles, and steer clear of things like tassels on rugs and telephone cords that could cause it problems. When it's finished, it nips back into its "docking" station and recharges itself for next time. You could almost say it has a mind of its own!

How does Roomba work?

Roomba's makers, iRobot Corporation, describe their creation as a "vacuum cleaning robot"—and that's a fair and accurate description. Just like the industrial robots that weld cars in factories, it follows a series of preprogrammed instructions, but it also uses a certain amount of built-in "intelligence" to work out what it needs to do and how it needs to do it.

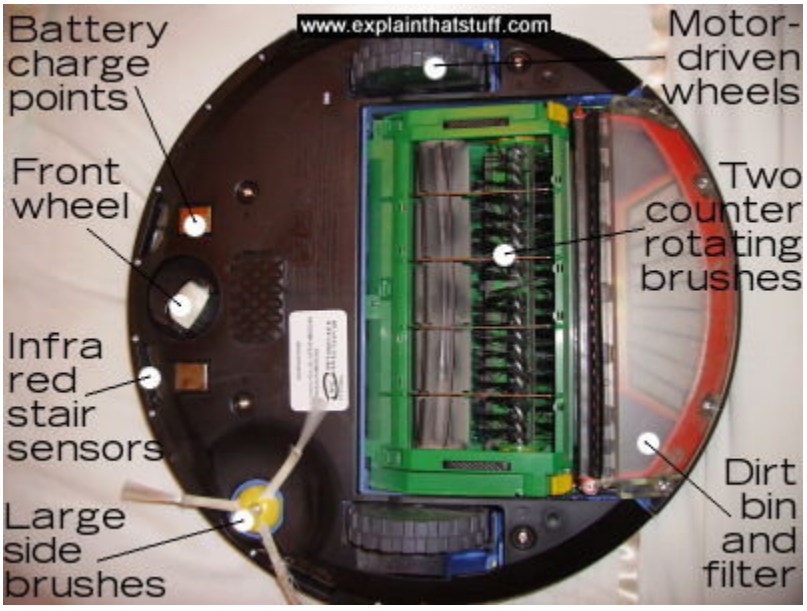


Photo: Turn your Roomba over and this is what you'll see underneath. The dirt bin, filter, and brushes are very easy to remove for cleaning.

Random bounce

Watch Roomba for a short time (it's hard not to) and you might think it's following a completely random

pattern. Most of the time it is! According to one of iRobot's original patents for the Roomba, the optimum way for a robot to clean a room is to use a combination of two main patterns: "wall following" (where it moves around the walls of your room, using its side-mounted, flailing brush to clean right into corners) and "random bounce" (where it cleans until it hits an obstacle, then moves off again in a random direction). The original Roombas (like the model 560 pictured here) seem to use several different cleaning modes, including sweeping across a room at speed to clean large areas, spiraling outward to cover larger spaces, and repeatedly retracing over areas that are particularly dirty (there's a flash of Roomba's bright blue "dirt detect" light to let you know when this happens).

Onboard sensors

Photo: Turn Roomba upside down and you'll see the infrared "cliff" sensors underneath the sturdy plastic case, which prevent Roomba from tumbling down stairs. It cleans right to the edge of stairs but never falls over! The white blob you can see on the right is the pivoting front wheel. The black curved edge at the bottom of the picture is the touch-sensitive front bumper.

Just as humans use our five senses to interact with the world, so Roomba has various onboard sensors to help it figure out what it can about your room. Mounted on top of Roomba, at the very front, there's a prominent infrared beam and photocell sensor. Immediately underneath, there's a plastic front bumper with a built-in touch sensor. The infrared beam detects walls and obstacles so Roomba slows down when it gets near them. The touch-sensitive bumper stops Roomba when it actually hits things. There are also infrared sensors mounted underneath, pointing straight downward, so Roomba can detect what it calls "cliffs" (stairs and steep drops). If it feels its brushes might tangle up on tassels or cables, it stops them rotating straight away and drives itself to safety.

How does Roomba know when it hits a particularly dirty patch? According to iRobot's patents, it uses a piezoelectric sensor (essentially a crystal that generates electrical impulses when things strike it). When bits of dirt hit the sensor, they generate tiny electric impulses and, presumably, an excessive number of these impulses triggers "dirt detect," causing the robot to retrace its steps, cleaning a little bit more slowly and thoroughly second time around. (Roomba's designers considered using an optical sensor to measure the dirt being sucked through the machine, but decided that would clog up too quickly and prove less reliable.)

Some Roomba models come with little standalone beacons called Virtual Wall® Lighthouses™, which are like flashlights that send out invisible, infrared beams. Use them in lighthouse mode and they help Roomba understand where one room ends and another begins, so it can clean one room properly before moving to the next; use them in "virtual wall" mode and you can set up barriers the robot isn't allowed to cross. Frankly, it's

easier just to close doors and put down books or brushes to pen your Roomba into certain areas—but possibly not as much fun!

Mapping

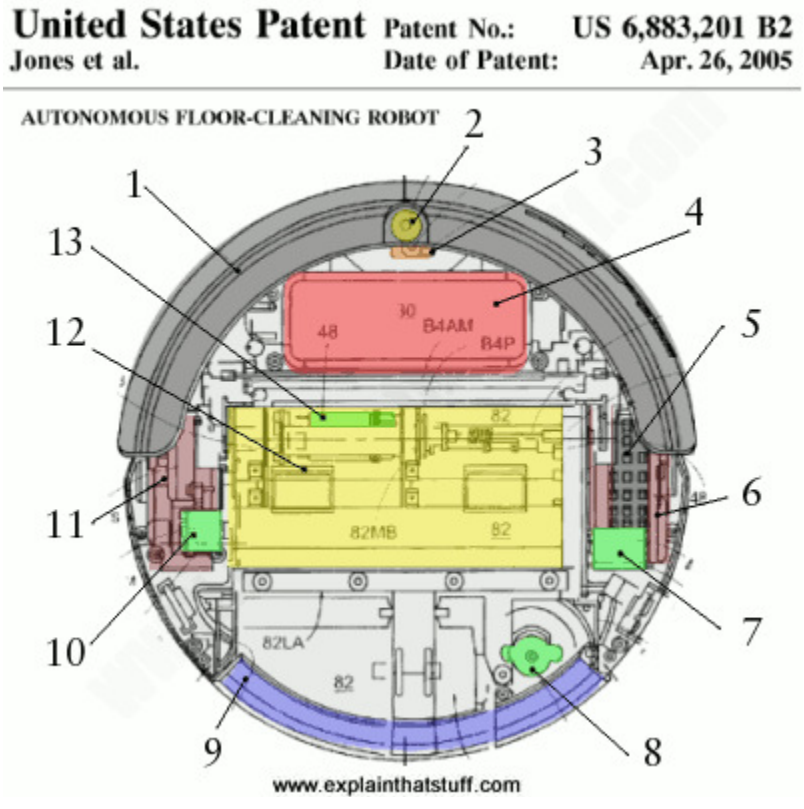
The original Roombas (like the 560) cleaned almost entirely randomly: contrary to what you might think, they didn't build "mental maps" of your rooms or your home. That's why cleaning took so long and was a bit haphazard. Newer versions (like the Roomba 980) have moved away from random cleaning to a much more intelligent approach called VSLAM (Vision Simultaneous Localization and Mapping). They use onboard infrared cameras to take snapshots of your room, gradually building up a picture so they know where they're going and where they've been. That means they can clean more quickly and thoroughly—and, unlike original Roombas, move in more confident straight lines (like a human cleaner would vacuum). It also means they can stop vacuuming when the battery is low, nip to the charger for a few hours, and then pick up where they left off when they've refilled with juice!

Wireless connectivity

The latest Roombas also offer handy Wi-Fi connectivity, which means you can program them from your smartphone or tablet with a simple app—even when you're away from home.

What's inside a Roomba?

Here's one of the technical drawings from iRobot's original patent for the Roomba, showing a few of the other key components that you can't see on the photo up above. I've colored and simplified it so it's a little easier to understand. Here we're looking down on the top of the Roomba, with the dirt bin toward the bottom and the infrared detector at the top.



Artwork from US patent#6883201: Autonomous floor-cleaning robot by Joseph Jones et al, iRobot Corporation, courtesy of US Patent and Trademark Office. This patent was filed December 16, 2002 and granted April 26, 2005.

1. Obstacle detection bumper at the front.
2. Infrared detector for communicating with lighthouses and docking station.
3. Wheel drop sensor.
4. Lithium metal-hydride rechargeable battery pack (14.4 volts and 3600mAH). This isn't normally visible—and you have to remove several screws on the case if you decide to replace it.
5. "Knobby" treaded wheels provide extra traction on smooth floors and help to prevent tufts from carpets and rugs snagging in the wheels.
6. Wheel sub-assembly.
7. Electric motor drives right wheel.
8. Electric motor powers vacuum.
9. Handle for removable dust bin.
10. Electric motor drives left wheel.
11. Wheel sub-assembly.
12. Self-contained brush mechanism.
13. Electric motor powers brushes.

Is Roomba any good?

Most people are skeptical, initially, and then very surprised by how effective Roomba can be. The secret is that it spends far longer cleaning a room (typically 25 minutes) than most of us would care to spend with a conventional vacuum cleaner and drives over each area several times. Generally, it does a much better job than you might suppose, but it has its pros and cons, as you'd expect.

Photo: This is one of the lighthouse/virtual wall gadgets that comes with your Roomba. You stand this at the edge of your room and it sends out an infrared beam straight ahead (just like a lighthouse). In virtual wall mode, Roomba will never cross the beam; in lighthouse mode, it will cross the beam once it thinks it's spent enough time cleaning your room.

Advantages

Unlike many electronic gadgets, Roomba is amazingly simple to use. Once its onboard battery is fully charged, you simply press the big, green, illuminated CLEAN button and off it goes. That's it! If you have a house without too much clutter on the floors and plenty of space around your chairs and sofas, Roomba should (in theory) clean everywhere without any help at all. It's much lower than a conventional vacuum and can easily creep under tables and chairs. It's fairly compact and much lighter to carry around your home (from the ground floor to the upstairs) than something like a big and clumsy Dyson, so it's likely to be a hit with elderly people who find large vacuums too heavy to handle. You can safely leave a Roomba to vacuum the first floor of your house without worrying about it falling down the stairs: it will clean right up to the edge of a step without falling over.

Drawbacks

Rather than precisely measuring and marking out your room, the original Roombas clean in what we might call an "intelligently random fashion." This works really well, given enough time, but that's the snag: it can take quite a long time (half an hour or more) to completely clean a room—and even then it can still miss bits. Newer Roombas have intelligent mapping to help solve this. Other drawbacks? Roomba can't move furniture out of the way to clean behind it, vacuum stairs, clean crumbs from inside your sofa, or anything of that kind. If you're the sort of person who always moves furniture when you're cleaning, this machine may leave you feeling your house is only being part-cleaned. It also has a fairly small dirt bin and the various brushes and filters inside it need a bit more checking and cleaning than you might devote to a conventional vacuum. You could find yourself spending more time cleaning your Roomba than you'd normally spend vacuuming your room!

If you have a pet, you might find two issues with a Roomba. First, the hairs will repeatedly clog up the bristles, so cleaning the machine will become quite a chore. Second, if your pet makes a mess on the floor, your Roomba will drive straight through it and spread it around your home. A small, localized problem can instantly turn into a much bigger issue.

Although Roombas claim to be able to stop themselves getting tangled up in wires, I've found that that isn't always the case. They can tug on telephone cables, mangle up dangling chains on vertical blinds, and get caught up on rugs with loose tassles. I'd recommend keeping your machine well away from areas where there are obvious loose ends to jam up the mechanism—just as you'd avoid them with a conventional vacuum. Either use one of the lighthouses to create a "virtual wall" or construct a physical barrier to keep your Roomba clear of the obstacle (lad down a broom or something else that your Roomba can't climb over).

Batteries can also be an issue. A new Roomba will happily clean away for somewhere between one and two hours. After weekly use for a year or two, you may find the battery power dipping down to as little as 30–40 minutes, which may not be enough to clean even a single room. Replacement batteries are available direct from Roomba, but they're relatively expensive; unbranded replacements are much cheaper, but there are dubious comments about them on online review sites—and you may conclude the extra cost is worth it. You'll also find it a good idea to follow the official Roomba guidelines and keep the machine permanently sitting on the charger. If you leave the machine off the charger, even a fully charged battery will leak away to nothing after a day or two, for no obvious or good reason. (My experience is that you do this too much, you quickly ruin the battery.) Be sure you clean the machine very thoroughly each time you use it and make sure all the brushes turn smoothly, with no compacted fluff jamming the bearings: the more resistance the brushes encounter from dirt, the harder the motors have to work and the shorter the battery life.

Photo: Disadvantages: Roomba has a very small dirt bin that fills up quickly, but it takes only a moment to empty it. Cleaning the brushes and filter takes a little longer. Although you don't necessarily have to do that every single time you use the machine, it's a good idea to keep the mechanism clean so the battery lasts longer.

Verdict

Should you buy one? If you hate vacuuming and you like gadgets, this machine is definitely for you. If you have a cluttered house with lots of stuff on the floor, give it a miss: you'll spend more time getting your home ready for Roomba than you save in the end. Personally, I think it's a great idea for routine cleaning, especially if you have a relatively uncluttered apartment with no stairs, so Roomba can clean everywhere in one go. I can see conventional vacuuming will still be needed as well—only a little bit less often than before. Now I'd just like a robot that does the washing, ironing, cleans the bathroom, and cooks my dinner!

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- Robots
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Articles

- iRobot Brings Visual Mapping and Navigation to the Roomba 980 by Evan Ackerman and Erico Guizzo. IEEE Spectrum, 16 Sep 2015. Exploring the new mapping and app features of the latest-generation Roombas.
- The secret military technology inside the household robot vacuum cleaner by Nick Glass and Matthew Ponsford, CNN, 31 March 2014. Where did the Roomba's designers get their inspiration?
- What became of the personal robot? by Danny Wallace and Peter Leonard, BBC News, 16 December 2008. How do robots match up with humans for doing household chores?

Videos

- Video Tour: All of iRobot's Coolest Stuff by Evan Ackerman. Be sure to check out the video embedded in this article, in which iRobot's Nancy Dussault Smith takes us on a 25-minute tour of the many different robots created at iRobot, including early versions of the Roomba.

Patents

I'm a great believer in learning about inventions by reading patents: that way, you get to discover exactly what the inventors were thinking and what they were trying to achieve, often in their own words. The Roomba in our house has seven US patents listed on its base. If you want to find a definitive explanation of Roomba's various features, check them out:

- US patent#6883201: Autonomous floor-cleaning robot: This is the main Roomba patent, with lots of diagrams showing you the various components inside in great detail.
- US patent#6594844: Robot obstacle detection system
- US patent#6690134: Method and system for robot localization and confinement
- US patent#6809490: Method and system for multi-mode coverage for an autonomous robot
- US patent#6956348: Debris sensor for cleaning apparatus
- US patent#7173391: Method and system for multi-mode coverage for an autonomous robot
- US patent#7196487: Method and system for robot localization and confinement

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