

Robot: Robonaut 2

The first humanoid robot to go to outer space

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Program



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[Outer space](#) is a dangerous place for [astronauts](#), especially when they need to venture out for a [space walk](#)—usually to do [maintenance](#) and repairs on their [spacecraft](#) or other [satellite](#). [Robot](#) helpers can make space safer for astronauts, and they can take over some of the boring or difficult jobs that astronauts do as well.

With this in mind, Robonaut 2 was designed by [NASA](#) to work alongside humans in space. It's been on the [International Space Station \(ISS\)](#) since 2011, when it arrived aboard the *Discovery* [space shuttle](#) on its last mission.

Robonaut 2 is currently being tested in the Destiny [laboratory](#) on the ISS. Scientists and [engineers](#) are working to understand how the robot behaves in zero [gravity](#) and how it performs simple tasks, such as measuring air flow in the space station, or flipping switches on a taskboard.

For safety reasons, astronauts onboard the ISS are trained in emergency medicine and basic surgery—but no matter how much medical training they have, most astronauts are not medical specialists, and the ISS is far away from any hospital! That's why researchers at NASA hope Robonaut 2 could be used in telemedicine. Telemedicine is the practice of a doctor or other medical professional in one place providing [health care](#) to a patient in another place. Researchers think Robonaut 2 may one day be controlled by doctors here on Earth to care for sick or injured astronauts on the ISS. A version of Robonaut 2 in Houston is already being trained to perform medical tasks such as using a [syringe](#) and conducting an [ultrasound](#) imaging test.

Although it's still early, the hope is that Robonaut 2 will one day be able move around the space station, give medical care to the astronauts, perform scientific experiments, and [venture](#) outside to help with repairs and install new parts on the ISS.

The [technology](#) developed for Robonaut 2 could also be useful here on Earth. Imagine using it to help in a [disaster](#), assist medical professionals in caring for patients in [remote](#) locations, or for high-precision, repetitive tasks, such as testing blood samples.

Why does Robonaut 2 look the way it does?

Since the space station was built for humans, having a human shape allows Robonaut 2 to move around the space station with ease and use the same tools as its human co-workers. The robot doesn't need any special [devices](#) of its own, and it can work with most objects already on the space station. Since the ISS has limited indoor space and it's expensive to ship things there, every tool has to count!

Robonaut 2's [humanoid](#) shape also makes it a more comfortable companion for its human coworkers. Since astronauts have to work for long periods in close quarters with Robonaut 2, it's important that they are comfortable being around it. Let's face it: You'd probably rather be buddies with a humanoid robot than with a clunky piece of metal.

Robonaut 2 was specially designed to be safe for humans. This is why it's covered in a soft material, and why it is [program](#)med to sense when a human is touching it and act accordingly. (Touching the robot's arm will stop it in its tracks, for example.)

What can Robonaut 2 do?

Torso

Initially, Robonaut 2 had only an upper body—a head, [torso](#), arms, and hands—attached to a support post. This upper body is slightly more than a meter (3 feet) tall, and weighs 150 kilograms (330 pounds).

To sense its environment, Robonaut 2's head is loaded with four cameras, two of which provide “stereo vision” to sense the depth of objects in its environment. Stereo vision compares image data from two vantage points—just like human eyes. The combined data allows us—and Robonaut 2—to see in 3-D. Robonaut 2's two extra cameras can be used if the other ones break down.

Robonaut 2 also has an infrared camera located in its mouth, which it uses to determine distance. [Infrared radiation](#) allows Robonaut 2 to sense how far away other objects are from it. The robot can move its head left and right, up and down, in order to see around itself.

Robonaut 2 can work safely alongside people thanks to “force [sensors](#)” that give it a sense of touch. Touching the robot's arm will stop it in its track, for example. Robonaut 2 also has sensors that tell it where its limbs are. In all, Robonaut 2's upper body has more than 350 sensors!

Arms and Hands

Robonaut 2's arms and hands were built to [manipulate](#) objects similarly to how people do. Each of Robonaut 2's arms can lift 9 kilograms (20 pounds) on Earth, and have a wide range of motions. Its

hands are also very agile for a robot. The video shows it flipping switches and pressing buttons.

Legs

In September 2014, NASA sent a set of legs to the ISS so that Robonaut 2 could move around the space station more easily. Astronauts removed the support post from the torso and attached the legs instead.

Robonaut 2's legs are very long—stretching about 2.7 meters (9 feet) when fully extended! They are very flexible, with seven joints each. This new hardware will make it possible for the robot to move around the space station, and even take space walks.

Since there is no walking in zero gravity, Robonaut 2's legs function more like an extra set of very long arms with devices on the ends (end-effectors) that allow the robot to attach to different parts of the space station. Robonaut 2 can even see through cameras on its feet!

Brain

Robonaut 2's brain is housed on a set of computers located in its torso.

The robot can work autonomously, meaning that all its decisions are the result of a program that reacts to sensor information and sends commands to its motors. It can also be remote-controlled, or tele-operated, by an astronaut on the ISS or a person back on Earth.

What can't it do (yet)?

Robonaut 2 is still being tested on simple tasks at the space station and is just getting used to its new pair of legs. Once it's mastered these, Robonaut 2 will be used for simple maintenance tasks on the ISS (like cleaning railings) until it's ready for its first space walk.

NASA is also looking for ways to let Robonaut 2 explore other planets or moons. One idea is to mount Robonaut 2's upper body on a rover that can navigate planetary surfaces. The Robotnaut 2 on wheels looks just like a Centaur—and it turns out, that's its name!

Vocabulary

Term	Part of Speech	Definition
agile	<i>adjective</i>	active and quick to respond.
astronaut	<i>noun</i>	person who takes part in space flights.
autonomous	<i>adjective</i>	self-governing.
computer	<i>noun</i>	device designed to access data, perform prescribed tasks at high speed, and display the results.
device	<i>noun</i>	tool or piece of machinery.

Term	Part of Speech	Definition
disaster	<i>noun</i>	terrible and damaging event.
engineer	<i>noun</i>	person who plans the building of things, such as structures (construction engineer) or substances (chemical engineer).
flexible	<i>adjective</i>	able to bend easily.
gravity	<i>noun</i>	physical force by which objects attract, or pull toward, each other.
hardware	<i>noun</i>	computer machinery.
health care	<i>noun</i>	system for addressing the physical health of a population.
humanoid	<i>adjective</i>	having human characteristics or form, or resembling a human being.
infrared radiation	<i>noun</i>	part of the electromagnetic spectrum with wavelengths longer than visible light but shorter than microwaves.
International Space Station (ISS)	<i>noun</i>	satellite in low-Earth orbit that houses several astronauts for months at a time.
laboratory	<i>noun</i>	place where scientific experiments are performed. Also called a lab.
maintenance	<i>noun</i>	support or upkeep.
manipulate	<i>verb</i>	to manage a complex device or situation with great skill.
moon	<i>noun</i>	natural satellite of a planet.
NASA	<i>noun</i>	(acronym for National Aeronautics and Space Administration) U.S. agency responsible for space research and systems.
navigate	<i>verb</i>	to plan and direct the course of a journey.
outer space	<i>noun</i>	space beyond Earth's atmosphere.
planet	<i>noun</i>	large, spherical celestial body that regularly rotates around a star.
program	<i>noun</i>	set of coded instructions for the automatic performance of a task provided to a robot or computer.
remote	<i>adjective</i>	distant or far away.
robot	<i>noun</i>	machine that can be programmed to perform automatic, mechanical tasks.

Term	Part of Speech	Definition
rover	<i>noun</i>	vehicle that remotely explores a region, such as the surface of a moon, planet, or other celestial body.
satellite	<i>noun</i>	object that orbits around something else. Satellites can be natural, like moons, or made by people.
sensor	<i>noun</i>	instrument that receives a signal and transmits data about that signal, such as data on light or heat.
spacecraft	<i>noun</i>	vehicle designed for travel outside Earth's atmosphere.
space shuttle	<i>noun</i>	vehicle used to transport astronauts and instruments to and from Earth.
space walk	<i>noun</i>	physical activity outside a spacecraft in orbit.
syringe	<i>noun</i>	small device consisting of a hollow needle and tube, used for extracting or injecting fluid into the body.
technology	<i>noun</i>	the science of using tools and complex machines to make human life easier or more profitable.
torso	<i>noun</i>	body, excluding head and limbs. Also called a trunk.
ultrasound	<i>noun</i>	sound emitted at frequencies above what humans can hear.
venture	<i>verb</i>	to take a risky or dangerous opportunity.

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