Name: _____ Date: _____

How Do Robots Work?

Reading level 11 (7th grade) · 1346 words

A class of sixth graders stands behind a yellow line in a college robotics lab. On the bench, an arm waits beside a cup with a raw egg in it. Lena, the student giving the tour, asks for the question everybody came with. A boy in front asks it. How do robots work? Lena says one thing first. A textbook from a university says it is essential: a robot moves in the real, physical world. Then she holds up three fingers.

The first finger is senses. A robot has sensors, and sensors measure things. In each joint of an arm, a part called an encoder measures how far the joint has turned. Other sensors measure force, or find objects with cameras and lasers. Lena points to a poster of the Mars rover Perseverance. NASA counted 19 cameras on the rover alone. Sensing, she says, is how a machine finds out what is going on around it. Without sensors, a machine would be blind and numb.

The second finger is muscles, which engineers call actuators. Most of them are electric motors. A motor spins fast but twists weakly, so gears slow it down and make the twist stronger. Some machines use air or oil pushing in tubes instead. Lena lets a student turn a small gear by hand. Everyone feels how little effort a slow turn takes when the gears do the work. A muscle alone cannot decide anything, Lena says. It needs orders from somewhere.

The third finger is the brain, which is called the controller. The world standard for robot words says robot technology includes perception, reasoning and planning. The controller's best habit is feedback. It keeps measuring what the arm is really doing, compares that with what it should be doing, and fixes the motors. The textbook says feedback is used in nearly all robot systems. One maker says its arm updates 500 times a second, which is every two thousandths of a second by our arithmetic.

Lena taps the cup, and the egg rocks a little. An egg is a hard test because it punishes both mistakes. Hold it too loosely and it drops. Hold it too tightly and it breaks. Engineers at Columbia built a system with pressure sensors that measure touch and change the grip as they go. A university magazine reported that in tests it picked up eggs and grapes. Amazon says its Vulcan arm uses force sensors to stay below the point where it could damage something.

A girl asks why so many robots roll instead of walk. Lena has an answer from June 2015. A US government contest tested robots on a disaster course, and IEEE Spectrum reported that walking on two legs was still really hard, while rolling was really easy. Most of the robots that fell were not badly damaged, but getting back up was probably the hardest job of all. Wheels, IEEE Spectrum added, give better stability and a much lower risk of falls. Lena draws a tall

stick figure on the board and tips it, to show why balance matters.

Walking robots have improved, Lena adds. In 2022 a two-legged robot named Cassie ran 100 meters in 24.73 seconds at Oregon State University, and Guinness World Records counted it as a record. It started standing, finished standing and never fell. Its knees bend like an ostrich's. The school says it did this with no cameras or outside sensors, almost as if blind. That was one run on one track, and records get beaten, so this is the record as of 2022. Lena writes the year beside the time.

How does an arm know where its hand is? Lena sketches one on the whiteboard. The controller reads each joint's angle. Since it knows the length of every link, it can work out the position and tilt of the hand. That sum has a name, forward kinematics. A solid object in space has six degrees of freedom, so six numbers fix where it is and how it is tilted. That is why many arms, like one maker's collaborative arm, have six turning joints.

Lena puts Mars on the wall screen. NASA says a radio signal takes anywhere from four to 22 minutes to cross between Earth and Mars, so a rover is not driven in real time. The wait changes as the two planets move around the Sun. Planners send a list of commands for a whole Martian day, called a sol. Then they wait, because they cannot be sure anything happened until the rover sends data and pictures back. Imagine steering a toy car with a twenty-minute wait between the push and the move.

So Perseverance, a six-wheeled rover with nobody aboard to drive it, drives itself. Its system, AutoNav, takes pictures of the ground while the rover rolls and builds a 3D map of hazards. Then it plots a course between waypoints that planners on Earth have picked. NASA's team calls this thinking while driving. The first Mars rover, Sojourner, judged its path using 20 measurement points. Perseverance uses 600,000 with every look. Lena writes both numbers on the board and lets the class compare them.

On October 11, 2026, Perseverance passed the old distance record for another world, 28 miles, set by the rover Opportunity. NASA says Perseverance took about five and a half years. Opportunity needed almost 15. NASA says the rover drove most of the way with AutoNav, its self-driving system. But it has limits. One engineer says glare in the navigation cameras is why the rover parks by mid-afternoon when it drives toward the Sun. People still choose where it goes. NASA expects the rover to keep adding to the record.

In December 2025 NASA tried something new. Generative AI planned the waypoints for two drives, a job that human planners usually do by hand. The rover drove both routes, and NASA says these were the first drives on another world planned by AI. Before any command went to Mars, engineers ran the plan through a digital twin, which is a virtual copy of the rover. They checked more than 500,000 pieces of its data to be sure the plan fit the rover's software. A machine suggested the route, and people checked it first.

At the back of the lab, a robot cell sits behind a fence, with tape on the floor around it. Lena says why. OSHA, the US workplace safety agency, says many robot accidents happen during programming, maintenance, testing, setup or adjustment, when a worker may be inside the robot's reach. Fences and light curtains are still used. A light curtain is a sensor that watches a gap and stops the robot if anything steps through. Rules for factory robots, rewritten in February 2025, now also cover machines that share space with people, using hand guiding, speed monitoring or limits on force.

Lena ends with two honest warnings. First, robots are not as capable as videos make them look. The International Federation of Robotics says about 7,000 full-size humanoid robots were sold for work in 2025, and most uses are narrow and often need a person to control them from far away. It says robot AI for many jobs is not ready for factories yet. Second, some robot toys come with apps. The US consumer protection agency, the FTC, lists a child's private facts as a full name, address, phone number, email address, location, photos, videos and voice recordings. In 2025 it said one toy maker's app had allegedly let an outside company collect children's locations without telling parents.

So Lena's rule for the class is plain. Do not type your full name, address, school or photo into a robot's app. If an app asks where you are, say no, and ask a grown-up to set it up. Then she sets the egg in its cup in front of the arm. Your turn, she says. What would this arm have to sense, and what would it have to decide, before it could pick that up? The class goes quiet. Then a girl at the back says touch.

Questions

1. Why is an egg a good test for a robot hand?

A. It punishes holding too loosely and too tightly
B. It is the heaviest thing a robot can lift
C. It cannot be seen by a camera

2. In this book, "feedback" means the controller

A. turns off the motors
B. measures what the robot does, compares it with the goal and corrects
C. sends a picture to Earth

3. Why can NASA not drive Perseverance in real time?

A. Its wheels are too slow
B. It has no cameras
C. Radio signals take minutes to reach Mars

4. What does AutoNav do between the waypoints planners pick?

A. It plots a safe course using a 3D map of hazards
B. It waits for each command from Earth

C. It decides where the science goals are

5. Why did engineers check the AI-planned route in a digital twin first?

A. The rover was out of power

B. To be sure the plan fit the rover's software before it was sent

C. Mars rovers cannot use waypoints

6. When does OSHA say many robot accidents happen?

A. Only when robots are broken

B. While robots are shipped to a factory

C. During programming, maintenance, testing, setup or adjustment

Words to know

actuator: moving part

feedback: measure and correct

waypoint: route stop

sol: Martian day

encoder: angle sensor

Answer key: How Do Robots Work?

1. A. It punishes holding too loosely and too tightly
2. B. measures what the robot does, compares it with the goal and corrects
3. C. Radio signals take minutes to reach Mars
4. A. It plots a safe course using a 3D map of hazards
5. B. To be sure the plan fit the rover's software before it was sent
6. C. During programming, maintenance, testing, setup or adjustment