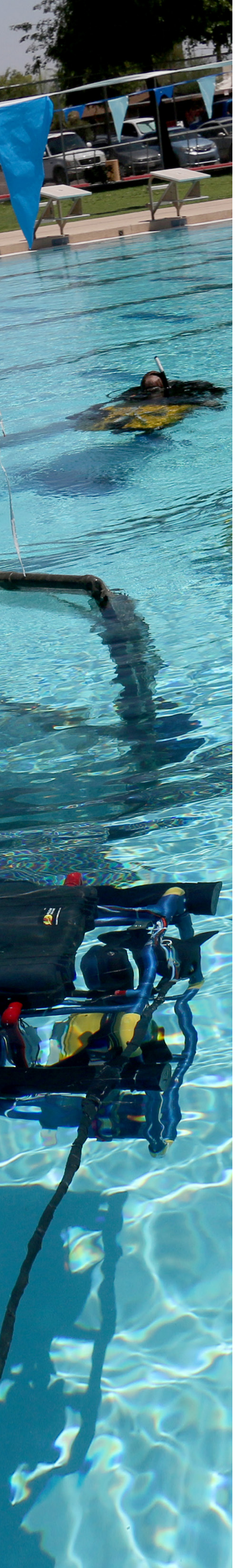


Grades
6–8, 9–12

45–90
minutes

DREAM BIG
ROBOT CHALLENGE

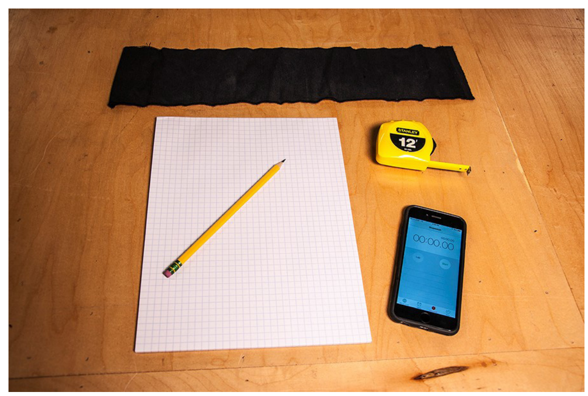
DESIGN CHALLENGE

Program a humanoid robot to successfully navigate an obstacle course.

SUPPLIES AND EQUIPMENT

Per whole group:
- ☐ Obstacles for obstacle course (chairs, desks, tables, trash cans, books, etc.)
- ☐ Stopwatch

Per team:
- ☐ Measuring tools: tape measure, ruler, or meter stick (at least 1 per team)
- ☐ 1 blindfold
- ☐ Graph paper
- ☐ Writing utensil



GETTING READY

An area of at least 400 square feet is recommended for this activity. Set up the obstacle course before participants arrive by placing tables, chairs, trash cans, and whatever else you're using throughout the space. Design the obstacle course so that participants must make at least one left turn and one right turn to complete it. The course does not need to be too complex but should have enough obstacles so that there is more than one path to the goal.

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INTRODUCTION

Explore these questions as a group:

What is a robot? (You will probably get a wide variety of answers from the group; this is good!)

Let the group know that if we asked a bunch of robotics experts what a robot is, we would get a wide variety of answers as well. Because of the complexity and variety of robots, it is nearly impossible to agree on one standard definition of what a robot is. Instead, we can talk about how a robot works.

According to the Robot Institute of America (1979), a robot is “a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks.”

Most machines do the same job over and over. To do it differently means building a different machine. Robots, on the other hand, can be made to do many different jobs by changing their programming.

How does a robot work?

Input: Robots use sensors to gather information about their surroundings. Sensors are devices that detect some type of information from a physical environment such as light, heat, pressure, motion, or sound. A robot’s sensors act just like our human senses, which give us information about our surroundings.

Program: Robots have a brain called a microcontroller. Humans create programs—instructions—that tell a robot how to respond to the input from its sensors.

Output: This refers to how the mechanical system, including motors, responds to accomplish the task(s) the robot has been programmed and sent to do, such as navigating around obstacles, picking up an object, or building a car.

INSTRUCTIONS

1. SET UP TEAMS.

Divide participants into teams of 3 or 4. Have them come up with a team name.

2. INTRODUCE THE DESIGN CHALLENGE.

You’ve been chosen to work with a team of engineers to explore a shipwreck, deep underwater on the ocean floor. The location is very treacherous and has a number of obstacles, so your team will be using a robot for this mission. Your team will need to program a robotic explorer to navigate through these obstacles to a specific point of interest. But be careful! The wreck is full of obstacles that can damage your robot. Avoid them and reach the destination for mission success.

INSTRUCTIONS (CONTINUED)

3. INTRODUCE THE OBSTACLE COURSE.

- Identify the starting point and the ending point (the point of interest on the ocean floor). You can mark these using masking tape.
- Identify the obstacles on the course that the robots need to avoid.

4. DESIGNATE TEAM ROLES.

Have each team assign roles to each participant:

- **Humanoid Robot:** One participant from each team is the robot. This team member will walk the course following the instructions from a programmer. The robot will only be able to hear the instructions; it will not be able to see the course or talk with the other team members during the mission.
- **Programmer:** The programmer is the person who will call out the instructions to the robot. The programmer will only be able to call out the program. He or she will not be able to see the robot move.
- **Observer(s):** The observer(s) watches the movement of the robot through and around the obstacles. The observer cannot talk to the other team members during the mission but should note how the team can improve the program.

5. PLAN THE PATH.

Instruct the teams to plan their path through the obstacle course using graph paper and measuring tools. During this phase of the mission, teams can use tools to create a map of the layout of the ship and determine the best path. Note to participants that in real life, engineers could do this by creating a life-size replica of the ship, by working with another ship that has a similar layout, or by working from a blueprint.

6. PROGRAM AND CALIBRATE THE ROBOT.

Now that teams have determined their path, they should program their robot to move through the path by writing a series of instructions. Encourage teams to use simple words and to be very specific in their directions.

- **Moving Forward:** Encourage teams to measure their robot's step length to begin to determine how many steps forward the robot should move along the path. Teams can determine the number of steps using this formula:

  Distance Needed to Travel ÷ Step Length = Number of Robot Steps

- **Calibrating Rotation:** Encourage teams to calibrate their turns by testing and refining their robot's rotational movement. Simple rotations are encouraged: 45-degree and 90-degree turns work best.

INSTRUCTIONS (CONTINUED)

7. EXECUTE THE MISSION.

Tell teams that it is time to execute their deep sea robotic exploration mission! One team at a time, teams should execute their mission. Blindfold the robot, and turn the programmer away from the obstacles so that he/she can't see the robot's movement. Only the observer(s) should be watching the robot as it moves through the course. If the robot is damaged by colliding with any obstacle, the team must stop the mission immediately and return to their planning area to "recalibrate" their robot's program. Using the stopwatch, see which team can complete the challenge in the fastest time.

ACTIVITY VARIATIONS

- **Trade roles:** Have team members change roles during the exercise.
- **Remotely Operated Vehicle:** Allow the programmer to see what the robot is doing and adjust instructions according to what is seen. In this variation, the robot acts as a Remotely Operated Vehicle (ROV), which is controlled more directly by humans.
- **Scaling up:** Have teams work from a scaled blueprint rather than the actual course to plan the robot's route.
- **Exploration location:** Change the location theme that your robot is exploring (e.g., to a volcano, another planet, a cave, etc.).
- **Environment change:** This activity can be done in a smaller area by using masking tape to create an outer border. To make it more challenging, design the course in an irregular polygon. You can also use different items for obstacles and change the rules for each obstacle. For example, "participants can/cannot crawl under tables or interact with objects."
- **Competition:** Vary how teams win the challenge (first team to complete, farthest distance traveled during tests, most accurate, shortest program, etc.).

TROUBLESHOOTING

- If teams are having trouble calibrating their robot's steps, encourage them to walk their steps by placing one foot directly in front of the other. This will help control the variations between strides.
- If a team's instructions are too complex, suggest they take a different path through the course, or help them simplify their terminology.

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RELEVANT TERMINOLOGY

Calibration: The process of carefully assessing, setting, or adjusting an instrument to ensure accuracy.

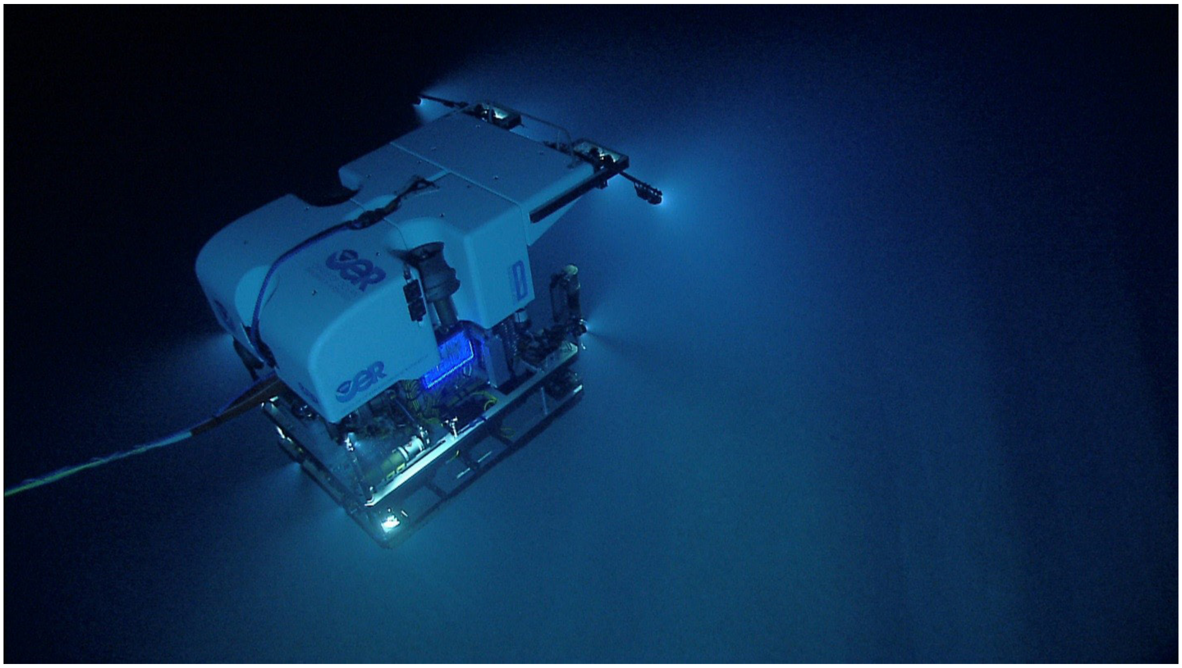
Humanoid robot: A robot with its body shape built to resemble that of the human body.

Iteration: The process of repeatedly testing and refining to reach a desired target or result.

Map: A representation of features of an area that shows them in their relative forms, sizes, and relationships.

Programmer: A person who creates and tests programs for devices including robots.

Programming: Creating a plan or schedule of activities and procedures to be followed.



Underwater robot called Deep Discoverer exploring the Atlantic Ocean. Image courtesy of NOAA Okeanos Explorer Program, Our Deepwater Backyard. Exploring Atlantic Canyons and Seamounts 2014.

GUIDANCE FOR YOUNGER CHILDREN

QUESTIONS TO ASK AFTER THE ACTIVITY

- How did your team choose a path? Were there other paths you could have chosen?
- How did your team decide how the robot would move? Were there other ways your robot could have moved that would have been faster?
- Did your program work perfectly the first time? If not, how did your team improve the program?
- Why did or didn't you give the robot each instruction separately?
- Were there programs that worked better than other programs? Why?
- How well did your team work together? How could you have improved your teamwork?

ENGINEERING CONNECTIONS

Robots are machines that help humans with tasks that are considered dirty, dull, dangerous, or distant. Engineers design, build, and program robots to work in specific environments, perform particular tasks, and conduct research.

Dirty tasks suitable for robots include cleaning up chemical spills or inspecting the insides of sewer pipes. Mowing the lawn or vacuuming are examples of dull jobs perfect for robots. Dangerous robotic tasks include bomb disposal and exploring harsh environments. Distant tasks include those at the bottom of the ocean or in outer space.

Robots are seen as perfect tools for deep sea exploration, which is both dangerous, due to the extreme pressure and temperature, as well as distant—sometimes more than a mile below sea level. Robots are also much cheaper to send into the deep ocean than humans, who need support systems such as air and heat to survive.

SCIENCE CONNECTIONS

Scientists study the properties of materials. At what temperature do they melt? How do they react under pressure? What happens when they freeze? Knowing this information is vital in designing robots that can hold up in extreme environments such as the bottom of the ocean. The pressure in the deep sea is 1,000 times that experienced at sea level, and the temperature varies from just above freezing to 750 degrees Fahrenheit at hydrothermal vents.

Materials scientists conduct a wide range of experiments designed to test the durability of metals and plastics under extreme conditions. Some types of steel and rubber become brittle at low temperatures, making them unsuitable for deep ocean exploration.

GUIDANCE FOR OLDER YOUTH AND ADULTS

QUESTIONS TO ASK AFTER THE ACTIVITY

- How did your team decide which path was the best? (Shortest? Fewest turns?)
- If the same robot/programmer team repeated the activity, would the path be exactly the same? Why or why not?
- What were the results of your first test? Did your team improve the program in between tests?
- Did you learn from any of the other teams' strategies? Did you add any elements of their program into your own?
- How well did your team work together? How could you have improved your teamwork?

ENGINEERING CONNECTIONS

Some robots must work with a high degree of precision. They are able to repeat dull, repetitive tasks over and over again with no variation. These robots function well in controlled environments such as a factory or lab.

Robots used in exploration, whether it is underwater or on another planet, must be programmed with a higher degree of flexibility. Currents can shift the position of the robot, or the robot can encounter unexpected conditions. Engineers program in suggested responses, such as telling the robot to back up or change direction when an obstruction is encountered. If this doesn't work, the robot may be programmed to wait for the humans to figure out a new set of directions.

SCIENCE CONNECTIONS

Understanding how animals are well adapted for a harsh environment can inform decisions made by engineers in designing robots for that environment. Scientists are using biomimicry to develop robots that look and act like living animals. Biomimicry develops solutions to human problems by imitating animals or biological processes. For example, Robolobster, a robot with 8 plastic legs, fiber-optic antennae, and a sturdy plastic shell, was originally used to study how a lobster's nervous system controlled its movements in the water. A lobster's body shape, weight, and buoyancy make it able to adjust to the changing currents, crashing waves, and low visibility of a coastal environment. By studying lobsters, scientists have been able to gain insight into how robots can be programmed to respond to similar conditions.

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