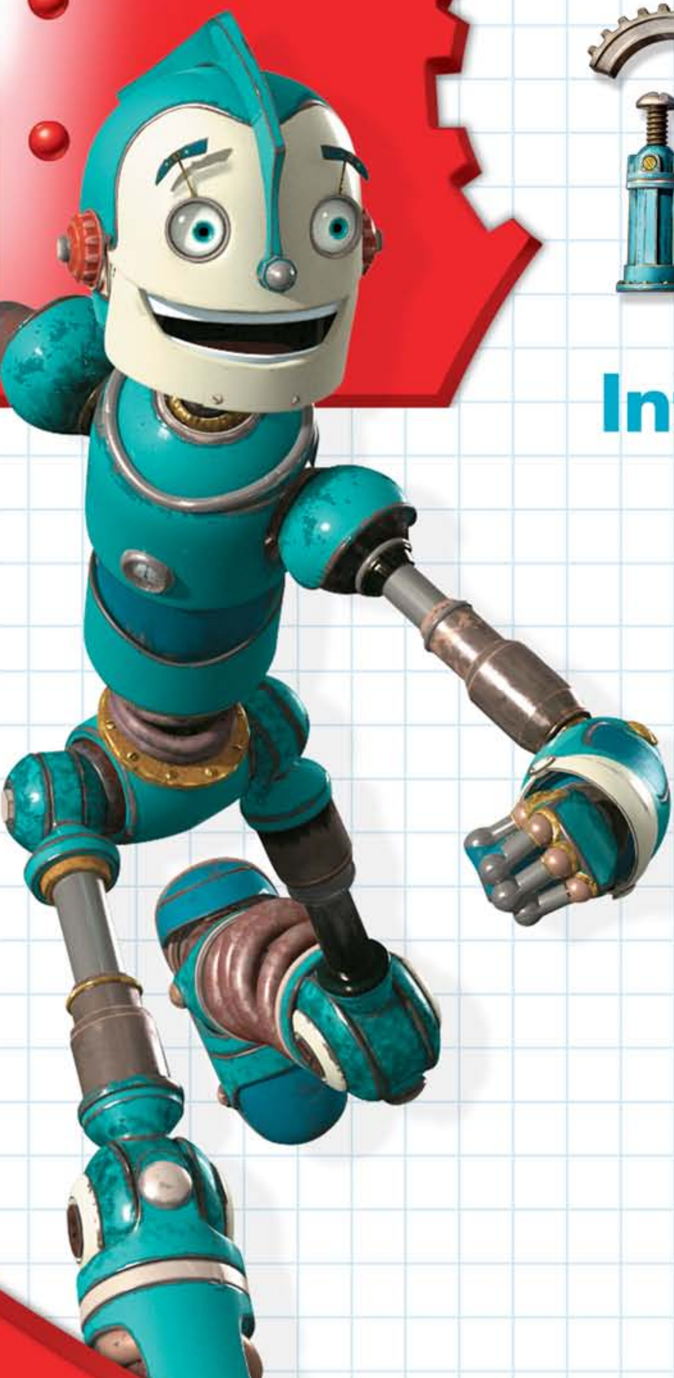


ROBOTS™ The Interactive Exhibition

Teacher's Guide

A booklet designed to help students learn through problem solving.

THIS EXHIBITION AND ITS NATIONAL TOUR ARE MADE POSSIBLE BY FORD MOTOR COMPANY FUND.

It's easy when looking at one of the characters from "Robots" to recognize it as a robot. It walks, talks, and acts just like a human—but it's made of metal.

But what makes something a robot in the real world? How close are we to making robots that act like Rodney Copperbottom, Fender, or Mr. Bigweld?

WHAT IS A ROBOT?

ro • bot n 1. A machine that looks and acts like a human being.

Merriam Webster Children's Dictionary, 2000

A robot is a metal man. Some robots build cars while others go to Mars. It is made of wires, circuits, and metal
James, age 11

I can t define a robot, but I know one when I see one. Joseph Engelberger, robotic pioneer

The fact of the matter is that it can be bit hard to define a robot. Characters from movies and television tend to look man-like, while real industrial robots may look more like a box on wheels. So what is a robot?

One functional definition says that a robot is a machine that performs a behavior usually associated with a living organism. Sometimes the parts of a robot can be compared to the parts of a person because they have a similar function.

HUMAN

MUSCLES
ARMS, LEGS
SKELETON
SKIN
SENSES
NERVES
FOOD, AIR
BRAIN
KNOWLEDGE

ROBOT

MOTORS, PISTONS
EFFECTORS - SPECIALIZED
TOOLS
CHASSIS
SENSORS
WIRES
BATTERY, FUEL CELL
COMPUTER
PROGRAM

According to the Robotics Institute of America, 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".

A robot does tasks. It is a manipulator—it moves things that can include tools, car parts, or cameras. A robot has a computer program that tells it what to do, and this computer can be reprogrammed to tell the robot to do a different task.

Your life has already been touched by robots and this trend will only continue to grow. You've probably ridden in a car that was built in part by robots. Automobile factories have used robots for the past 40 years. Robots make up 10% of the workers in some automobile factories. Robots are used to milk cows, wash windows, clean pools, inspect sewers, and dismantle bombs. They've explored other planets.

Robots are showing up in our homes as well, vacuuming carpets and mowing lawns. At the end of 2002 there were around 200,000 service robots in use in private homes world wide. By the end of 2003, the number was up to 610,000 and experts project that by the end of 2007 the numbers will exceed 3,500,000!

ROBOTS TIMELINE

The idea of a world inhabited by robots caught the imagination of filmmakers Chris Wedge and William Joyce. Many storytellers have used robots or mechanical men. Frankenstein's monster and the Tin Man from the Wizard of Oz are just two examples from books. Movie and television characters such as R2D2, C-3PO, and Mr. Data have shaped our imaginations.

Robots represent one of the areas where imagination and dreams have sometimes led the way. Long before the word "robot" existed and before computers and electricity were in use, humans dreamed of mechanical people. Ancient Egyptians were buried with stone statues that were supposed to come to life and do all the work in the hereafter. Jewish legends talked of golems, clay creations that could come to life magically. Greek mythology had Talos, a giant human-like figure made of bronze. He protected the island of Crete by racing around it three times daily. When enemies came to the island, he threw giant boulders at them.

Imagination and reality began to meet as technology improved.

1495 A.D.

Leonardo da Vinci
Leonardo da Vinci made sketches and plans for a robot. Dressed in a suit of armor, the robot was designed to open and close its jaw, sit up, wave its arms, and move its head. No records exist to show whether or not it was ever built.

18TH CENTURY EUROPE

Automatons—self operating machines—were popular. A mechanical duck could eat and defecate. Another automaton was capable of drawing four pictures and writing three poems.

1921

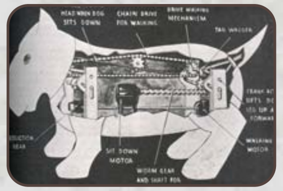
Human-like machines called "robots" are introduced in Karl Capek's play, Rossum's Universal Robots. Robot comes from the Czech word robota, which means forced labor or serf.

1932

Willie Vocalite
The Westinghouse Electric & Manufacturing Company built several early versions of robots. Willie Vocalite could sit down, stand up, salute, fire a gun, and smoke a cigarette. He could even speak, with a limited vocabulary.

1939

Elektro and Sparko
Elektro was built by Westinghouse. He was seven feet tall and weighed 280 pounds. He could walk, move his head and arms, distinguish colors, and could talk with a vocabulary of 77 words. Elektro appeared at the 1939 World's Fair. When he returned in 1940, he came with Sparko, a robot dog. Sparko performed tricks such as "sit" and "bark" on command from Elektro.



1941

Eniac, one of the first computers, is built. It occupied over 1,500 square feet—not very useful for operating a robot!

1941

Isaac Asimov writes "Runaround", a story about robots. The collection I, Robot appears in 1950.

1948

Elmer and Elsie

W. Grey Walter built a pair of robot tortoises, Elmer and Elsie. They contained touch and light sensors that could tell when the shell was rocked by bumping into something or when the other tortoise was nearby. Elmer and Elsie could operate without continuously human guidance.

1956

Father of Robotics

Fact and fiction met when inventors George C. Devol and Joseph F. Engelberger discussed the writings of Isaac Asimov. They decided to develop a real, working robot, rather than the simple, toy-like devices built to that point. Engelberger began a company—Unimation—with the goal of creating the first commercial robot.

1961

Unimate

The first industrial robot, Unimate, joined the assembly line at a General Motors plant. Rather than a humanoid robot, Unimate was a robotic arm weighing 4,000 pounds. Unimate took hot metal die castings from machines and performed welding on auto bodies. It followed step by step instructions stored on a magnetic drum. An industry was born. Unimate robots are still among the most widely used industrial robots in the world.

1966

Shakey

Begun in 1966, Shakey (named for its jerky movements) was the first mobile robot designed to move freely without help. Shakey had programs for seeing, reasoning, moving, and language. Its most significant accomplishment, however, was that it didn't require step-by-step instructions. It had the ability to take general information and decide how to accomplish the task.

FACT

Advances in electronics, including transistors (1940's) and integrated circuits (1960's), allow computers to get smaller and faster.

1976

Voyager I and II

Robotic arms are used on the Voyager I and II space probes.

1986

Jason Jr.

Jason Jr., a lawn-mower sized Remotely Operated Vehicle (ROV), was used to explore the wreck of the Titanic.

1994

Dante II

An eight-legged, rappelling robot, Dante II descended into the crater of Mt. Spurr in Alaska. Gas and water samples were analyzed and videos sent back to bases in Anchorage, Washington D.C., and San Francisco. It tested both the ability of robots to conduct volcanic research (8 vulcanologists were killed in 1993 alone) and how robots would function exploring other planets.

1995

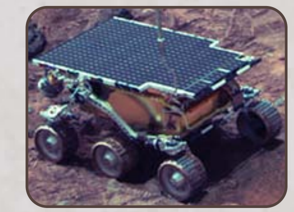
Cog

MIT's Artificial Intelligence researchers build Cog (a play on the word "cognition" and a mechanical cog) to look humanoid, working on the hypothesis that humanoid intelligence requires humanoid interactions with the world. Cog learns new tasks by trial and error, getting better upon repetition, just as a human does.

1997

Sojourner

The first interplanetary robot begins exploring Mars.



2000

ASIMO

ASIMO is the world's first humanoid robot to walk on two legs. It can walk forward and backward, turn while walking and climb up and down stairs.

2001

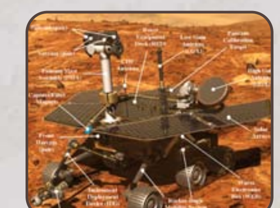
Search and Rescue Robots

Prototype robots from the Center for Robot-Assisted Search and Rescue helped search the rubble of the World Trade Centers for survivors. Traditional search cameras could only penetrate 18 feet. The search and rescue robots were able to go 60 feet through rubble that was still on fire.

2004

Spirit and Opportunity

After landing on opposite sides of Mars in January, both robots began sending images and testing rocks for the presence of water and life. Originally projected to work for 3 months, both robots were still operating over 18 months later.



2004

Robonaut B

NASA unveiled Robonaut B, the second version of a mechanical astronaut. Built with human-like hands and television camera eyes, Robonaut B can either roll around on a scooter base or use a "space leg" to plug into foot restraints on the International Space Station. Robonauts would work with astronauts, handling routine jobs such as installing foot restraints and laying out tools, cutting down the time astronauts would have to spend in the dangerous environment of outer space.

2005

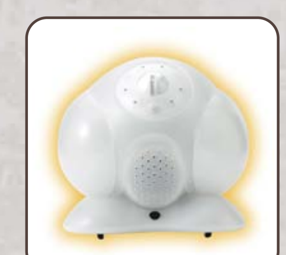
Self-replicating robot

Researchers at Cornell University unveil a self-replicating robot.

2005

Roborior

Roborior, a robot house sitter, went on sale in Japan. It contains infrared sensors, a videophone, a smoke detector, and a digital camera. When a problem such as an intruder is detected, it contacts the owner's video-ready mobile phone and sends an image.



IS IT A ROBOT?

GRADE LEVEL
Pre-school to early elementary

MATERIALS
- Dominos
- Outline of a shape such as a gingerbread man
- A light-weight ball such as a ping pong ball
- Making tape
- A wind-up alarm clock or other wind-up toy

National Science Education Standards

Science and Technology
- Abilities of Technological Design

BACKGROUND
Setting up dominoes to make patterns or do a job like turning on a light switch is Mr. Bigweld's favorite hobby. By setting up some simple patterns, students can see examples of cause and effect, and gain insight into the differences between robots and machines.

PROCEDURE
Place the dominoes on end, following the outline of the shape, so that when one domino falls over, it will knock down the rest in sequence.

Is this a robot? It moves and has a man-like shape. Is it a robot?

No, this isn't a robot. Shape isn't the most important characteristic of a robot. Robots must also do a job.

Use a piece of tape to make a straight line on a table, with one end going to the edge of the table. Put a ball on the line at the edge of the table. Line the dominoes up so that they knock the ball off when they topple.

Is this a robot? It did a job, like an old-fashioned alarm clock (wind up the alarm clock and set it off). But just like the alarm clock, it needs to be reset before it can do the job again. If it were a robot, it would be designed to pick up the dominoes and line them back up again and knock another ball off the table. And that takes some sort of computer brains and electrical power to accomplish.

TRACE AND RETRACE

GRADE LEVEL
All

MATERIALS
- Markers or crayons in different colors
- 5 sheets of thin or tracing paper per student
- Outline drawing of a simple shape such as a star or square

National Science Education Standards

Science as Inquiry
Σ - Abilities Necessary to do Scientific Inquiry

Science and Technology
Σ - Abilities of Technological Design
Σ - Understanding about Science and Technology

BACKGROUND
One of the benefits of robots is their ability to repeat a task in exactly the same manner over and over again without getting tired or bored.

PROCEDURE
Take a line drawing of a shape. Place a piece of tracing paper over it and copy the shape using a marker. Take the first piece of tracing paper off and repeat this with another sheet and paper and different color of marker. Do this several times.

Take all the tracings and hold them up to the light. Try to line them up. Where you able to trace the shape exactly the same each time? Robots can—up to thousands of times per hour, 24 hours a day, 365 days a year.

IT'S NOT AS EASY AS IT LOOKS

GRADE LEVEL
1st grade and up

MATERIALS
- Mechanical arm/gripper from a toy or hardware store
- Two sheets of paper

National Science Education Standards

Science as Inquiry
- Abilities Necessary to do Scientific Inquiry

Science and Technology
- Abilities of Technological Design
- Understanding About Science and Technology

BACKGROUND
Some robots operate independently. In order to do this, they are equipped with sensors and programming that allow them to make repetitive movements with a high degree of precision: lower arm 5.3 cm; rotate arm 181˚ counterclockwise; rotate screw 10 turns. Autonomous robots such as this work well within factory settings where the environment can be controlled.

Other robots need a higher degree of flexibility in their actions. Take tying shoelaces for example. Sometimes the loops fall to the right, sometimes to the left. While it's easy for us as human to decide how to adjust, it's hard for a computer program. It can take over 10,000 lines of instructions for a robot to tie a shoelace. For now, it's easier to tie it ourselves.

Robots that operate in remote or dangerous locations that contain unknown obstacles sometimes rely on human operators to make decisions. These robots are called Remotely Operated Vehicles or ROV's for short. ROV's have been used to explore the Titanic and detonate bombs.

PROCEDURE
Have a student get used to the mechanical arm by picking up a variety of objects. Note—results will vary depending on the type of arm used. Some devices will be stronger or more sensitive than others.

Place an object on one of the target sheets of paper. Have the student move the object from one target to another.

Once the student is familiar with the arm, bring up a second student. The first student is going to act as a robot ROV and follow the commands of the second student, the ROV Operator.

Blindfold the ROV student. The ROV Operator will give the ROV commands such as "Left", "Right", "Up", "Down". Once again, the student operating the mechanical arm will move an object from Target A to Target B, this time under the direction of the second student. Repeat this a few times. Does it get easier?

GOING FURTHER
Place obstacles between the two targets that require the ROV to go over or around them.

WHAT KINDS OF JOBS ARE BETTER SUITED TO ROBOTS THAN TO HUMANS?

GRADE LEVEL
All

MATERIALS
– Chalkboard, whiteboard, or overhead

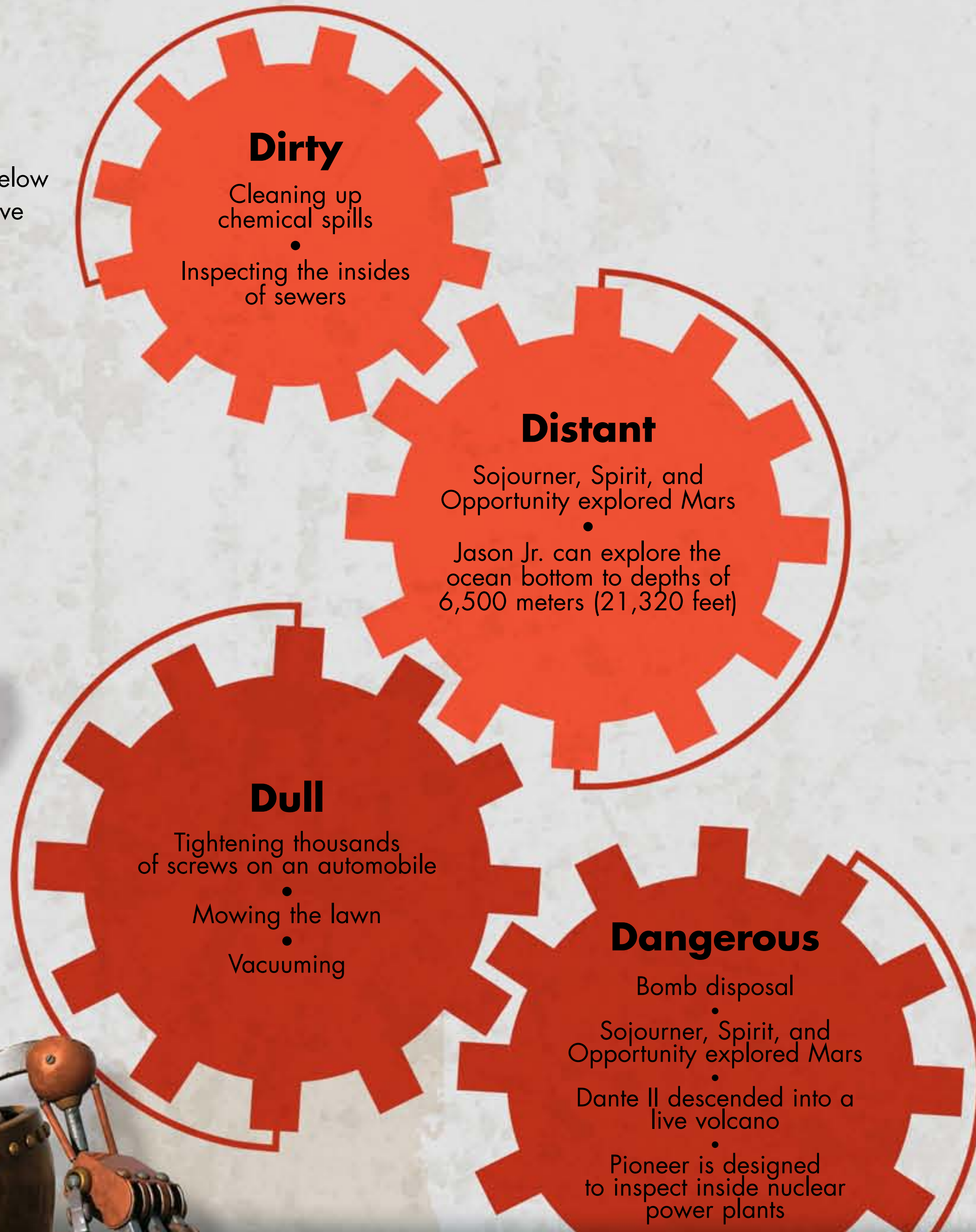
PROCEDURE
Copy the chart headings from below onto the board or overhead. Have students brainstorm ideas to fill the chart. Then share real life examples.

National Science Education Standards

Science and Technology
- Abilities of Technological Design

Science in Personal and Social Perspectives
- Science and Technology in Society

BACKGROUND
Robots are used to do jobs that humans couldn't or shouldn't do because of the 4 D's: Dirty, Dull, Dangerous, Distant.



SEE A NEED, FILL A NEED

GRADE LEVEL
All, with modifications

MATERIALS
– Paper
– Pencils, pens

National Science Education Standards

Science and Technology
- Abilities of Technological Design
- Understandings about Science and Technology

Science in Personal and Social Perspectives
- Science and Technology in Society

BACKGROUND
Rodney Copperbottom saw that his dad needed help on the job and began designing Wonderbot. It wasn't easy—it took time and lots of revisions to get it to work right, but he persevered until he was successful.

Scientists and engineers who design robots generally work in teams, with each team member handling a different task. Throughout the process, the team needs to work together so that the final product (a robot) can function as desired.

PROCEDURE
Pre-K to 3rd grade
Design a robot as a class under the teacher's direction, following the guidelines below.

4th grade and up
Divide the class into teams of 4-6 students. Each team member will identify a household chore and write a proposal explaining why this chore is suited to a robot, keeping in mind the 4 D's of Dirty, Dull, Dangerous, or Distant.

The teams will meet and review the proposals, deciding on project to design as a group.

Each team member will take responsibility for a different question and design a part of the robot to answer it.

- How will it move?
- What tools will it have to do the job?
- What holds it up?
- How will it sense its environment?
- Where does it get its energy?
- What kind of information does it need to know?

The team will get back together and share their ideas. Do any parts need to be modified so that they fit with other ideas?

Combine the parts into one robot and share it with the class. Include drawings and written explanations to answer all the questions.

GOING FURTHER
Build the robot out of recycled trash.

So Who Wants to Be Fixed?

Grade Level
All

Materials
- Paperclips
- Vegetable oil

National Science Education Standards

Physical Science
- Properties and Changes of Properties in Matter
- Transfer of Energy

Life Science
- Structure and Function in Living Systems

Science and Technology
- Understandings About Science and Technology

Background
In the movie "Robots", older robot models find themselves facing a problem when they can no longer buy replacement parts. But they're made of metal. Metal doesn't wear out—out does it?

Rust
Did you know the oxygen we need to survive is also a dangerous, corrosive chemical, both for metals and for humans?

When oxygen meets metal, it reacts and forms new, sometimes weaker, compounds. When the metal is iron, we say that it rusts. Bright shiny copper turns green. To prevent this, metals are often coated with some sort of protective barrier, such as paint or oil, to keep air from reaching the metal surface. In humans, oxygen can sometimes cause cell damage, which is why we eat vitamins with "anti-oxidants" to keep us healthy.

Metal Fatigue
When humans do 100 push-ups a day for a year, we get stronger. When a robot does 100 push-ups (or other movements), it can actually get weaker. If metal is put under repeated stress, its molecular structure changes, causing it to weaken and crack.

Try it yourself: Take a metal paperclip and straighten it. Now bend it sharply back and forth. How many bends does it take before it breaks? Gently touch the broken ends of the paperclip to your lips immediately after it breaks. What do you notice? (The ends should be warm.)

Lubrication
Wherever two moving parts meet, they rub. Rubbing causes friction, heat, and stress.

In humans, we call the places where moving bones meet joints. Joints have a number of features to reduce friction and wear. The ends of the bones are coated with cartilage, a springy, slick coating that reduces friction and cushions the joint. Some forms of arthritis occur when the cartilage wears away and the hard bones rub directly on each other. In addition to cartilage, joints also contain synovial fluid, which look like raw egg white. It nourishes the joint surfaces and reduces friction between them.

Try it yourself: Rub your hands together as hard and fast as you can. What do you notice? (accept all answers, but guide responses to notice heat). Put a few drops of vegetable oil on your hands and try again. What do you notice now? (it should be easier and there shouldn't be as much heat).

Career Profiles

Grade Level
All, with accommodation. Teachers can read the interviews and lead the discussion for younger students. Older students can read the interviews on their own and discuss the questions among themselves.

Materials
- Copies of the following interviews

Background
William Joyce is a leading writer, illustrator, and animator of children's books, movies, and television series. Besides the "Robots" movie, he has also created another world of robotic characters in the "Rolie Polie Olie" books and Emmy Award-winning television series.

Dr. Ayanna Howard is a robotics research engineer with the NASA Jet Propulsion Laboratory (JPL). She is currently developing software that will enable robots to choose where to land on Mars, and select the best paths for travel on the surface.

Dr. Edward (Eddie) Tunstel is a Senior Robotics Engineer at NASA JPL, working with Robotic Vehicles including the Mars Exploration Rovers (MER) Spirit and Opportunity.

Procedure
Read and discuss the following interviews. Consider the following questions:

What did they like to do when they were kids?

How did their interests grow into careers?

Do they like their jobs? How can you tell?

What kind of schooling did they have?

How much schooling do you need to do this kind of job?

Which jobs require imagination?

Which job lets you play in a sandbox?

William Joyce—Exhibit Text
"My dad says I was born with a pencil in my hand. I always loved drawing. I started out drawing really ugly pictures of my sisters. That was my "Ugly Sister" phase. Then I had my "Dinosaur" phase. Then I had my "Dinosaurs Eating Cavemen" phase (I used a lot of red during that one, with guts everywhere). Then I had my "Dinosaurs Eating My Sisters" phase. My parents never discouraged me. They let me take art lessons. There was never any talk about me growing up to be a rocket scientist or a plumber. It was apparent that I would be an artist no matter what.

I had two great art teachers: Mrs. Hogan and Mrs. Slagle. They were wise enough to just show me the possibilities and then let me figure stuff out by myself. If I got stuck, they'd help me out, but only when I was really stuck.

I quit art school and went to film school. I know I wanted to tell stories and since movies tell their stories through pictures (they don't call them moving pictures for nothing), I thought I would learn a different way of doing my artwork. I studied animation a lot. Sometimes I would write a story and draw pictures to go with it. It seemed only natural after college to try to do children's picture books, so I did. The funny thing is now I'm working on movies based on my books. I love what I do. It's like getting paid for recess."

<u>Roboticists Answer Our Questions</u>
Excerpted with permission from http://robotics.nasa.gov/home/students/robotics.php

What made you interested in learning about robots?
Ayanna Howard: When I was younger, I was fascinated by the television show: The Bionic Woman.

Eddie Tunstel: It started with a strong interest in drawing sketches of many different things, including robots and machines. Later, I combined that interest with keen interests in how things worked and, in particular, how things that moved worked. Once I became aware that one could control moving machines using computer programming, I wanted to learn how. I thought that learning how to make robots move under computer control was the coolest because they could be programmed to do so many useful things. It is challenging, however, which is a big part of my motivation.

What types of things do you get to do, being a roboticist?
Ayanna Howard: Program robots to have intelligent behavior. Test robot capability in simulated Martian environment. Think outside the box to develop, build, and test new innovations.

Eddie Tunstel: As a Senior Robotics Engineer, I perform research and technology development towards creating new capabilities for robot systems to be used for space exploration. This includes developing software that enables robots to navigate and perform useful function on their own using sensors and computers. In addition, I lead teams of different types of engineers (mechanical, computer, electrical, etc) who perform testing and operations projects that focus on autonomous robot systems. Finally, I get to help operate robotic systems (such as the MER rovers) to perform missions in space. I get many opportunities to apply my ideas to help solve new problems and then watch solutions develop on sophisticated, but fun, robotic systems that may one day operate in space or on other planets.

What is your working environment like? Do you work in a cubicle, outside, etc?
Ayanna Howard: I work in three environments—my office, lab, and in outside terrain (Mars Yard). Which environment I work in depends on whether I'm programming, testing or demoing the research.

Eddie Tunstel: I spend time in robotics laboratories around computers and robots trying out new ideas for improving the way they work or what they can do. Some of those labs have indoor sandboxes with rocks and soil in which I test how mobile robots (rovers) perform. Sometimes I perform the same work outdoors in desert locations that have terrain similar to that on Mars or whatever the potential destination of our robots may be. These days, I'm helping to guide the Mars Exploration Rovers, Spirit and Opportunity, as they explore on the Martian surface. For this job, I work in "mission control" rooms filled with computers and large screens. As for office space, engineers may work in cubicles, offices with closed doors, or wide open areas. It all depends on what facilities are available in the workplace….

Do you have any suggestions for younger kids, in grade school, who are interested in science and robotics?
Ayanna Howard: Find hands-on activities that get you excited—such as robot competitions and robotic kits (e.g. Mindstorm).

Eddie Tunstel: If you're interested in having similar fun…I mean doing similar "work", be sure to study math and science hard. If it doesn't come to you easily

find help and continue to work at it. To be a robotics engineer, it is necessary to understand high levels of math and science as well as how computers and machines work. If math and science are not fun by themselves, you can surely find enough fun and challenges to suit your needs by applying them to robots. The college and university degrees in major disciplines I mentioned above will provide a necessary background. Finally, tinkering with computers, robots, video games, etcetera is also a good use of time since you never really stop doing similar things in a career as a robotics engineer.

What courses did you have to take in high school and college in order to have a career in robotics?
Ayanna Howard: Math and physics (in high school). Math, engineering, and computer science (in college).

Eddie Tunstel: In high school, one just takes what is necessary to graduate and enter college; some exceptions are electives, if they are offered…If electives are offered, then those that involve hands-on work and study as well as application of math and/or science should be taken by students interested in robotics.

In college, one should choose to major in disciplines like engineering (mechanical, electrical, computer), computer science, or physics…..One should also consider graduate school after college to earn Masters and/or Ph.D. degrees in such areas. Such advanced degrees will allow one more control over what projects they work on and increase the opportunities for applying more of their own creativity. It is also important to study more than one of these disciplines because robotics is a multi-disciplinary field.

How many years of schooling (besides K-12) did you take in order to land a job as a NASA roboticist?
Ayanna Howard: 10 years (after high school) which includes 4 for undergraduate, 1 for Masters, and 4 for Ph.D.

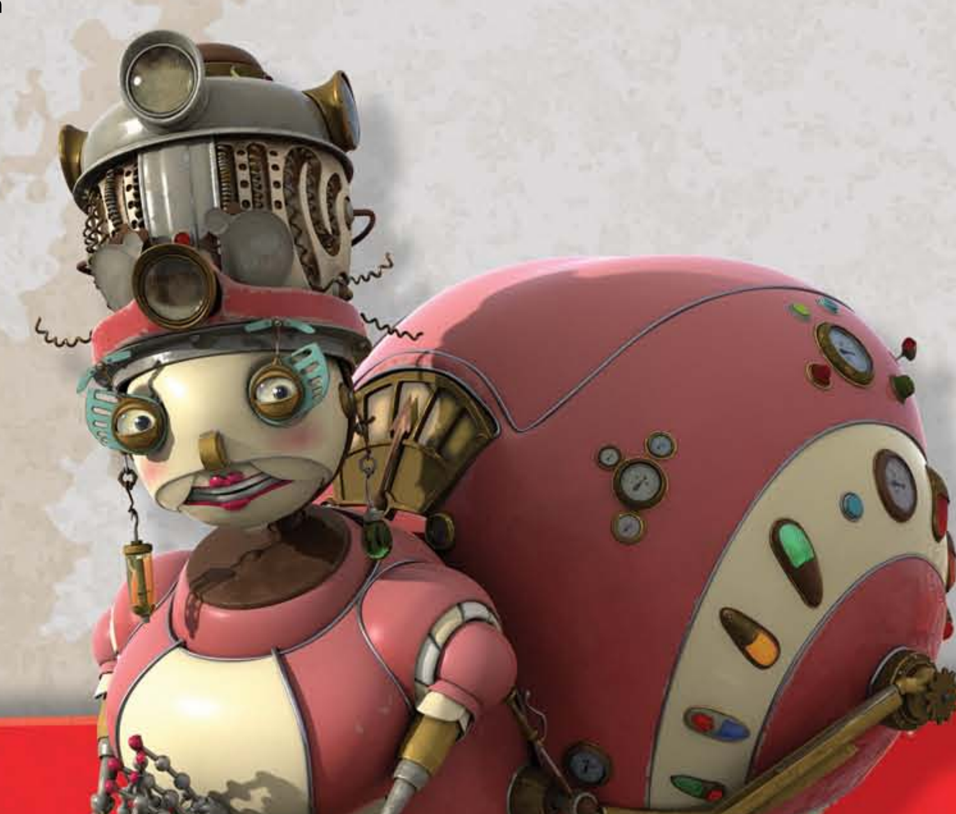
Eddie Tunstel: I had 5 years of college (which was supposed to be 4 years) studying mechanical engineering, which led to a Bachelor's degree. That can be sufficient for an entry-level position as a NASA roboticist. I then had over 2 years of graduate school studying mechanical engineering with a focus on robotics, which led to a Masters degree. That prepared me to work as a robotics researcher at NASA. I was hired by NASA JPL once I graduated with my Masters degree. I later completed a Ph.D. degree in electrical engineering with a focus on mobile robot control systems and navigation. That better prepared me to perform independent research at NASA based on my own ideas and lead teams of engineers in making new ideas become reality.

Going Further
For more resources about William Joyce, Ayanna Howard, Eddie Tunstell and other roboticists, see the Resources section.

National Science Education Standards

Science in Personal and Social Perspectives
- Science and Technology in Society

History and Nature of Science
- Science as a Human Endeavor
- History of Science



BUILDING YOUR OWN ROBOT

GRADE LEVEL
K-12

National Science Education Standards

Science as Inquiry
- Abilities Necessary to do Scientific Research
- Understandings About Scientific Inquiry

Physical Science
- Motions and Forces
- Transfer of Energy

Science and Technology
- Abilities of Technological Design
- Understandings About Science and Technology

Science in Personal and Social Perspectives
- Science and Technology in Society

History and Nature of Science
- Science as a Human Endeavor
- Nature of Science

BACKGROUND
There's nothing that will teach more about robots than actually building one yourself.

There are many robot curriculums and robot kits available for all grade levels. One of the largest projects is operated by FIRST—For Inspiration and Recognition of Science and Technology.

Dean Kamen, engineer and inventor, created FIRST to make science and engineering as interesting as sports to youth. Each team participating in a FIRST competition receives their robot kit on the same day, allowing about 6 weeks to solve a design challenge before attending a state or regional competition. The challenge changes every year, forcing experienced teams to continue to design new and innovative solutions. When teams come together for the competitions, they (and their robots) are randomly grouped with other teams, and given a few hours to decide on a strategy for success. Throughout it all, an emphasis is placed on "gracious professionalism", encouraging cooperation and civility.

Junior FIRST LEGO™ League
GRADES: ELEMENTARY
An introductory activity, JFLL allows younger students to explore, investigate, and build a model made with LEGO bricks. Each team builds a module and when they come together for the final event, the modules are joined into one larger unit.

FIRST LEGO League
GRADES: MIDDLE SCHOOL
Participants use **LEGO MINDSTORMS™** Robotics Invention System™ technology to build robots.

FIRST Robotics Competition
GRADES: HIGH SCHOOL
Students solve a common problem using a standard "kit of parts" to build a robot. In 2005, 25,000 students participated in 30 competitions around the world.

For more information about FIRST, Botball and other robotic curriculums, competitions, and kits, see the Resource page.

BIBLIOGRAPHY

For more information, check out:

The Tech Museum: Robotics: Sensing, Thinking, Acting
http://www.thetech.org/robotics/

Leonardo Da Vinci's robot model
Institute and Museum for the History of Science
http://brunelleschi.imss.fi.it/ingrin/index.html
Follow the links to Leonardo da Vinci, Models, 3D simulations for a unique look at what da Vinci's robot would have looked like.

RESOURCES

For more information, check out:

Robots in general

How Stuff Works
A good overview of robots and robotics.
www.howstuffworks.com/robot/

Manufacturing Is Cool, Society of Manufacturing Engineers
The K-12 educational area of the Society of Manufacturing Engineers.
www.manufacturingiscool.com

NASA: The Robotics Alliance Project
Find lesson plans, curriculum, competitions, and internships at this comprehensive site.
http://robotics.nasa.gov

Robot by Walter Bridgman
Dorling Kindersley Limited, 2004
A highly visual, easy to understand introduction to robots.

RobotCafe
Links and resources galore about robots, including hardware, software, cartoons, creative writing, competitions and more.
www.robotcafe.com

The Tech Museum: Robotics: Sensing, Thinking, Acting
Another good overview of robots, with animations and videos.
www.thetech.org/robotics/

Robot Supplies
ROBOTIX®
A motorized, modular construction system that allows children to build robots, robotic creatures, and robotic vehicles. Some ROBOTIX Sets have remote control capability and all sets are fully programmable.
www.roboticsandthings.com/

LEGO Mindstorms
LEGO MINDSTORMS for Schools integrates robotics and programming. Using the Mindstorms kit, students construct a robot and write an operating program for it. Mindstorms is used by several robotic competitions.
www.legomindstorms.com
(800) 763-2466

Robotikits Direct
A whole series of robots and robot kits for all skill levels.
www.robotikitsdirect.com/

Robot History
Leonardo Da Vinci's robot model
Institute and Museum for the History of Science
Follow the links to Leonardo da Vinci, Models, 3D simulations for a unique look at what da Vinci's robot could have looked like.
http://brunelleschi.imss.fi.it/ingrin/index.html

Robot Hall of Fame
The School of Computer Science at Carnegie Mellon University honors robots from science and science fiction. Past inductees include Unimate, Mars Pathfinder Sojourner Robot, ASIMO, Shakey, C-3PO, and Robby the Robot.
www.robothalloffame.org

Robot lesson plans and competitions

Botball
Middle school and high school students design, test, and build a robot to play a game. Participating teams/robots meet in a non-destructive competition.
http://www.botball.org

FIRST (For Inspiration and Recognition of Science and Technology)
Students build a robot to meet a design challenge. Efforts culminate in regional competitions. There are different challenges for elementary through high school.
www.usfirst.org/robotics

RESOURCES

Robot people

William Joyce
"Meet the Artists—William Joyce", National Center for Children's Illustrated Literature, www.nccil.org/joyce.html

The World of William Joyce Scrapbook by William Joyce.
Laura Geringer, 1997

Roboticists Ayanna Howard, Eddie Tunstel, and others
"Innovators: Rise of the Machines"
Time Magazine On-line, Tuesday, June 8, 2004

"Roboticists Answer Our Questions"
http://robotics.nasa.gov/home/students/robotics.php

"Who's Who at the FIDO Field Site"
http://mars.jpl.nasa.gov/mer/fido/sol25-image1.html

"Zip Code Mars Contribution"
http://zipcodemars.jpl.nasa.gov

Picture riddles

Can You See What I See? By Walter Wick
Scholastic Inc.

I Spy books by Jean Marzollo
Scholastic Inc.

Look-Alikes by Joan Steiner
Little, Brown and Company