Robotics in the Classroom
Introduction to Robotics

A collaborative unit for 5th and 6th grade students

in science, math, and language arts

Wright Patterson Air Force Base

Educational Outreach Office

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Acknowledgements

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Robotics in the Classroom is a multi-year project sponsored by Wright Patterson Air Force Base to bring real-world applications of science and math concepts to the traditional classroom. The Educational Outreach Office at WPAFB is committed to motivating students to explore the world of science and technology, and to increasing student awareness and excitement in all fields of math, science, aviation and aerospace

Table of Contents

Curriculum Overview

Summary

Today, more than any other time in history, robots play a significant role in everyday life. For the average person it is impossible to go through a day without coming into contact, one way or another, with a robotic device. This unit introduces fifth and sixth grade students to the development of robotics during the 20th and 21st centuries while illustrating the prevalence of robots in the world today. Students will use the scientific method to develop their own designs for a robot that could be useful in daily life. Although the subject of robotics is extremely vast, we have selected just a small portion to cover in this unit. Teachers should plan three to four weeks to cover the lessons that follow, excluding the transfer activity.

Big Picture

To get the most from this unit, we advise arranging for a guest speaker to come to your classroom and give a brief introduction to the field of robotics. In addition to sharing real-world knowledge and anecdotes, a speaker will be able to answer students' questions and generate excitement about the subject they will be studying for the next few weeks. Prior to the beginning of the unit, teachers should make their own robot to show the students.

Obtaining Classroom Guest Speakers

Guest speakers and demonstrations may be available for your classroom from Wright Patterson Air Force Base in Dayton, OH. Wright Patterson supports community and educational outreach by either direct visitation to classrooms or distance learning venues. For more information, contact the Educational Outreach Office at Wright Patterson Air Force Base:

(voice) (937) 904-8622
(email) Educational.Outreach@wpafb.af.mil

Preparation for the Unit

Science, math, and language arts teachers will cooperate to:

1. Secure guest speakers. Consider resources such as parents of students, military personnel, local businesses, and hobbyists. There are many clubs and organizations based on robotics.

2. Find an engaging video that discusses the progression of robotics thorough the 20th and 21st centuries, and introduces major concepts and terminology. One suggested video is Let's Talk Robotics (15 min., grades 3-8) from NASA's Liftoff to Learning series.

3. On-line resources for free videos include:

    - NASA Robotics Educational Project http://robotics.nasa.gov/
    - The Lunar Rover Initiative from Carnegie Mellon University http://www.frc.ri.cmu.edu/projects/lri/
    - The Organic Robot from Circuit Cellar Magazine – an easy first robot to build with everyday items. http://users.aol.com/TheOrganicRobot/Organic.pdf
    - NASA Jet Propulsion Lab on-line videos of robotic space exploration http://www.jpl.nasa.gov/technology/images_videos/robotics/robot_index.html
    - NASA JSC ROVer Ranch – Interactive website and robot primer for children. http://prime.jsc.nasa.gov/ROV/library.html

4. Build a sample robot available for the opening activity. (See the appendix for details on how to locate a good kit, or use the organic robot at http://users.aol.com/TheOrganicRobot/Organic.pdf)

5. Since the unit is a collaborative effort among language arts, math, and science teachers planning ahead is necessary. Teachers must understand how their lessons fit into the big picture.

6. Make photocopies of the handouts and activity pages found in this unit.

Unit Overview

The following overview includes a brief summary of each Authentic Learning Task (ALT), and provides a synopsis of the tasks required in each of the three sections. The table also cross-references the collaboration of concepts addressed in the teaching disciplines of science, math, and language arts.

Unit Overview

Section I History and Uses Of Robots	Section II Components of Robots	Section III Design of Robots
ALT 1 – Robot Uses (Science) Students will examine, through video and discussion, the multiple uses of robots--past, present, and future.	**ALT 1 – Physics and Robotics (Science)** Students will demonstrate an understanding of the relationship among mass, force, work, power, and energy, and how those terms have an impact on the selection of robotic components.	**ALT 1 – Robot designing using the Scientific Method (Science)** Students will apply knowledge of the process of the scientific method as they design a new type of robot.
ALT 2 – Instruction Sequencing (Math) Using logic and sequence, students will write instructions to complete given tasks.	**ALT 2 –Robot Programming (Math)** Students will be introduced to the different kinds of robot sensors. Students will use distance formulas and ratios, instead of a sensor, to be able to tell a robot how far to move.	**ALT 2 – Robot Design Sketch (Math)** Students will make drawings of their robot using the concepts of proportion and scale.
ALT 3 – Examining Robotic History Through Writing (Language Arts) Students will infer the impact robots have had on society throughout history, and demonstrate their knowledge and opinions through writing.	**ALT 3 – Critical Thinking: What Makes a "Good" Robot? (Language Arts)** Students will use prior knowledge of robotic components to write a detailed description of the robot they want to design.	**ALT 3 – Evaluation: Was your Robot a "Good" Robot? (Language Arts)** Students will evaluate, through writing, the design of their robots. They will compare and contrast their design with that of an already existing robot.

Transfer Activity

Upon conclusion of the unit, students will be able to apply what they have learned to real world problems by building and programming their own robot. They will start with their own robots designed in the unit, and modify them based on the equipment available to them in a robot kit. The goal is to build a robot that can accomplish given tasks. Because of the increasing popularity of robots, several types of robotics competitions are available throughout the country. Check on-line for local competitions, or call the Educational Outreach Office at Wright Patterson Air Force Base for more information.

Many companies produce robot kits, one of which is the MindStorm™ Robotics Invention System. This transfer activity is written specifically for this kit because of its versatility and popularity, but does not constitute an endorsement of LEGO® products. The transfer activity can be modified for other available robot kit.

History and Uses of Robots

ALT 1: Robot Uses

Summary:
After watching a video and/or completing research illustrating the many uses for robots and describing their components, students will participate in a class discussion listing major uses and functions of robots.

Competencies:
Upon completion of this lesson, students will be able to:

1. List possible uses of robots, and common components.
2. Identify robots in the students' everyday life.

Time:
Approximately two hours

Materials:

- Student rubric
- Video showing the progression of robotics through history, plus introducing major concepts and terminology. A suggested video is Robot Revolution (27 min., grades 1-7) available at http://www.libraryvideo.com for $14.95. On-line resources include:
  - A short history of robots http://prime.jsc.nasa.gov/ROV/history.html
  - The History of Robotics http://cache.ucr.edu/~currie/roboadam.htm
  - Others as listed on page 5.

Instructions:

1. Present video to the class, stopping for discussion as necessary. Students are to make a chart listing facts learned from the video. The goal is to find 10 or more facts.
2. Brainstorm about and list, as a class, the different uses and components of robots, as seen in the video.
3. Extend the activity by having the students make a list of robots they see outside the classroom in everyday life. This can either be a take-home activity, or class activity, depending upon the time available.
4. Discuss the students' findings from the above activity.

Evaluation/Assessment of Student Competency:
Student competency is based on criteria detailed in the rubric on the following page.

Closure:

Discuss how the robots seen in the video differ in mode of locomotion (ways of movement), size, task capability, and speed. Encourage students to move towards the recognition that there is a relationship among the things that have been mentioned. This relationship will be further explored the next time you meet.

History and Uses of Robots ALT 1: Handout One

Robot Uses Rubric

	Beginning 0	**Developing 1**	**Accomplished 2**	**Exemplary 3**	**Score**
List possible uses of robots, and common components.	Student does not list any uses or components	Student lists four or five uses and components	Student lists between six and eight uses and components	Student lists between nine and twelve uses and components	
Identify robots in the student's everyday life	Student does not list any examples of robots	Student lists four or five examples of robots	Student lists between six and eight examples of robots	Student lists between nine and twelve examples of robots	
Extract facts from the video	Student finds no facts from video	Student finds 3-5 facts, and/or chart is not neat	Student finds 6-9 facts, and chart is neat	Student finds ten or more facts, and chart is exceptional	

History and Uses of Robots

ALT 2: Instruction Sequencing

Summary:

Using logic and sequencing, students will write instructions to complete given tasks. This lesson is designed to not only develop the students' logic, sequence, and problem solving skills, but will be used to introduce the concept of robotic programming.

Competencies:

Upon completion of this lesson, students will be able to:

1. Write instructions for a partner to follow to complete given tasks.
2. Follow written instructions to complete a given task.
3. Reflect on the activity, summarizing what worked well, and what did not.

Time:

Approximately three hours

Materials:

Paper, pencil, photocopies of ALT 2: Handout One (A and B) and rubric

Instructions:

1. On a separate piece of paper, students will write instructions for their partners to follow to complete one of the given tasks listed on the student worksheet. Instructions must be very detailed and specific. Partners will follow these directions to the letter, so nothing must be omitted or implied.
   - A sample task and directions should be given by the instructor to show the expected product. (A sample task and directions is found at the end of the lesson.)
   - The teacher should assign one task from the worksheet for students to use, or have the teams decide individually which task to attempt.
   - A variation of the fourth task listed on the student worksheet may be a class group activity. Physically make a maze in the room for students to navigate.
2. Each student will take turns reading the directions to his/her partner. Student partners will then attempt to complete the given task, following the instructions exactly.
3. If students are unsuccessful in completing the task, have them make adjustments to the directions and try the task again.
4. When one task has been successfully completed, then both students will write instructions for all of the tasks, have them completed successfully by their partners, and complete the reflection questions at the end of the worksheet.

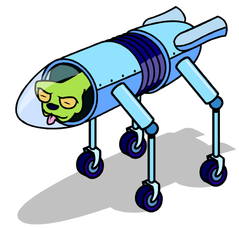
Evaluation/Assessment of Student Competency:

Student assessment will be based on criteria found in the rubric on the student handouts.

Closure:

A class discussion will follow the activity. This discussion should focus on the reflection questions, and on the similarities/differences between the activity and robot programming.

Instruction Sequencing



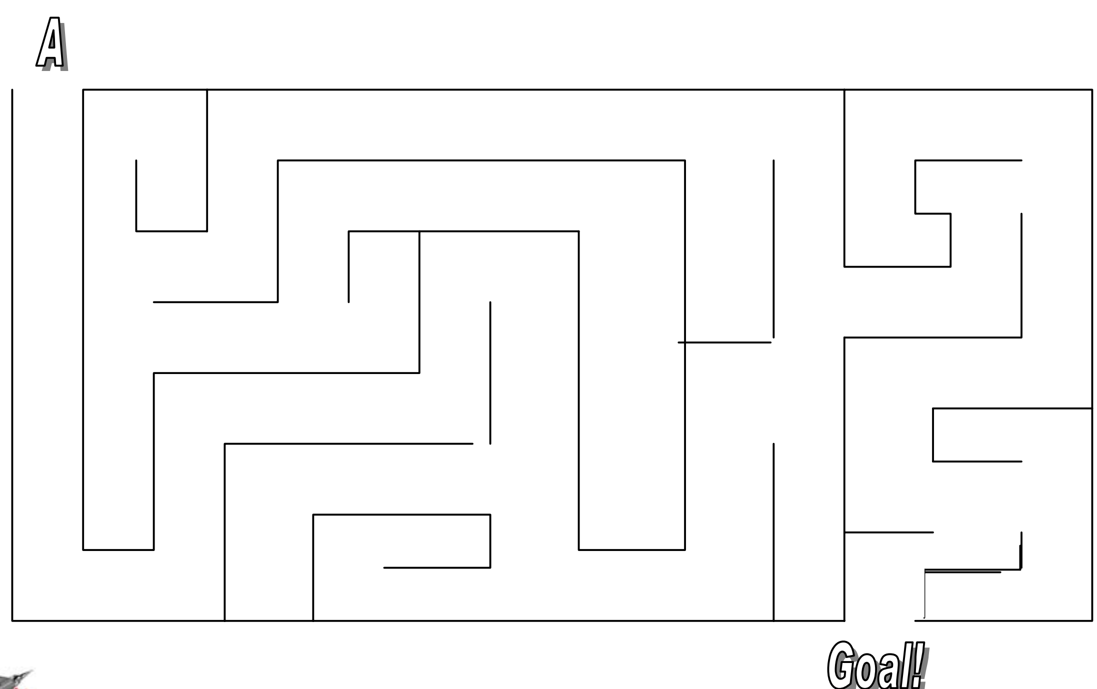
Directions:

1. You will work in teams of two. On a separate piece of paper, write instructions on what movements to make to complete task #1 below. Instructions must be detailed and specific. Your partner will follow these directions to the letter, so nothing must be omitted or implied.
2. One person will be the "programmer". The programmer reads the instructions. The other person will be the "robot" and will do exactly what the instructions say to do. The robot will try to complete the given task following the instructions exactly.
3. Did it work? If the "robot" could not complete the task, make adjustments to your directions and try the task again. Continue to modify your directions until the task can be completed successfully.
4. Write instructions for the rest of the tasks below. Take turns reading the instructions to each other while he/she tries to complete the task. When your partner can complete all the tasks successfully by following your directions, then complete the reflection questions at the end of the worksheet.

Tasks:

1. Pick a pencil up off the table and place it in your pocket.
2. Take the pencil from your pocket, sharpen it, and return it to the table.
3. Walk up a flight of stairs, turn around, and return down the stairs.
4. Go through the maze from point "A" to the "goal".

Maze:



Reflection Questions:

1. What was the most difficult part of writing the directions for the robot?
2. What directions confused your robot the most?
3. What directions were the best for helping your robot complete the task?
4. What are some examples of specific directions that you needed to give your robot to enable him/her to complete a task?
5. How did you tell your robot when to stop, turn, reverse, etc.?
6. Would you have written your directions differently if you were writing them for a real robot to follow?

Writing Instructions Rubric

	Beginning 0	Developing 1	Accomplished 2	Exemplary 3	Score
Written Directions	Many steps omitted and/or are not detailed nearly enough.	Some steps omitted and/or are not detailed enough.	Includes appropriate steps and details	Steps were thorough and descriptive.	
Following Directions	Did not follow the written directions and was uncooperative.	Was cooperative but did not follow the directions word for word.	Was cooperative and followed directions.	Was cooperative, followed directions, and offered suggestions.	
Reflection Questions	Answers were not well thought out or grammatically appropriate.	Answers were well thought out, but not grammatically appropriate.	Answers were well thought out.	Answers were extensive, well thought out, and detailed.	

Instruction Sequencing

Worksheet B, page 1

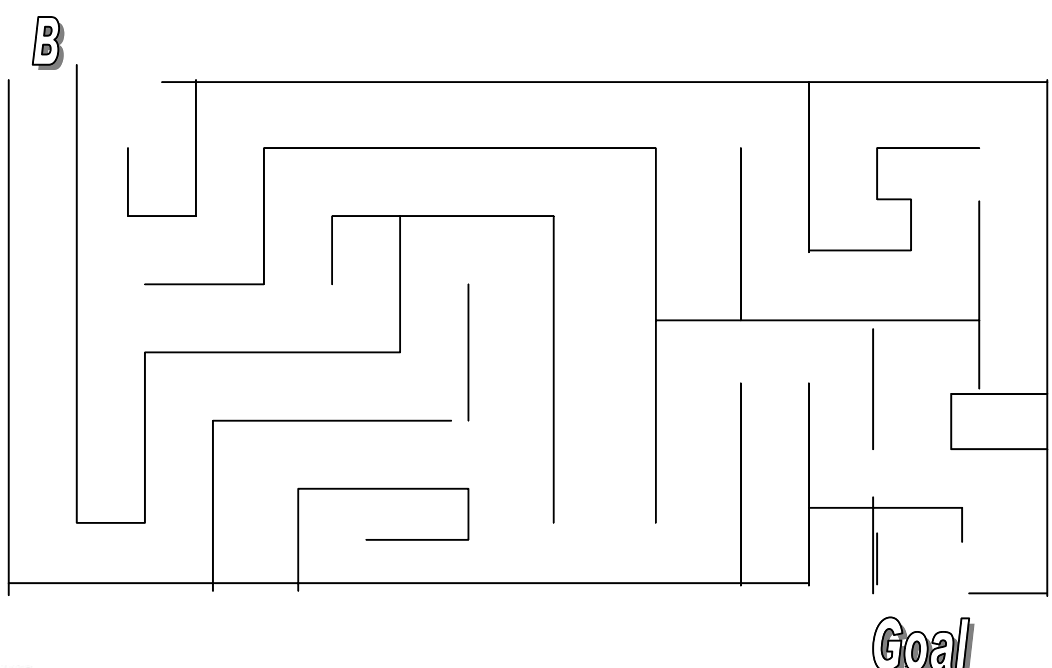
Directions:

5. You will work in teams of two. On a separate piece of paper, write instructions on what movements to make to complete task #1 below. Instructions must be detailed and specific. Your partner will follow these directions to the letter, so nothing must be omitted or implied.
6. One person will be the "programmer". The programmer reads the instructions. The other person will be the "robot" and will do exactly what the instructions say to do. The robot will try to complete the given task following the instructions exactly.
7. Did it work? If the "robot" could not complete the task, make adjustments to your directions and try the task again. Continue to modify your directions until the task can be completed successfully.
8. Write instructions for the rest of the tasks below. Take turns reading the instructions to each other while he/she tries to complete the task. When your partner can complete all the tasks successfully by following your directions, then complete the reflection questions at the end of the worksheet.

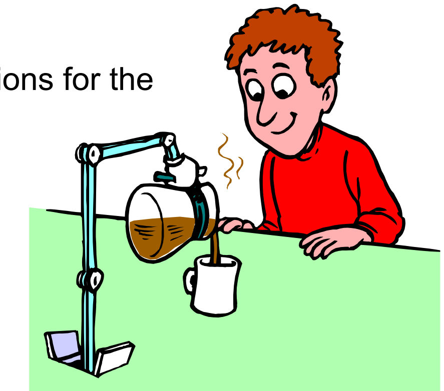
Tasks:

1. Open a book to the table of contents.
2. Close the book and place it on a table on the other side of the room.
3. Put a piece of scrape paper in the trash can/recycling bin.
4. Go through the maze from point "B" to the "goal".

Maze



Reflection Questions:



1. What was the most difficult part of writing the directions for the robot?
2. What directions confused your robot the most?
3. What directions were the best for helping your robot complete the task?
4. What are some examples of specific directions that you needed to give your robot to enable him/her to complete a task?
5. How did you tell your robot when to stop, turn, reverse, etc.?
6. Would you have written your directions differently if you were writing them for a real robot to follow?

Writing Instructions Rubric

	Beginning 0	Developing 1	Accomplished 2	Exemplary 3	Score
Written Directions	Many steps omitted and/or are not detailed nearly enough.	Some steps omitted and/or are not detailed enough.	Includes appropriate steps and details	Steps were thorough and descriptive.	
Following Directions	Did not follow the written directions and was uncooperative.	Was cooperative but did not follow the directions word for word.	Was cooperative and followed directions.	Was cooperative, followed directions, and offered suggestions.	
Reflection Questions	Answers were not well thought out or grammatically appropriate.	Answers were well thought out but not grammatically appropriate.	Answers were well thought out.	Answers were extensive, well thought out, and detailed.	

Teacher's Sample Task

Sample Task:

Pick up a glass of water and take a drink.

Directions:

1. Lift your hand so that it is about two inches above the table.
2. Rotate your hand so that the thumb is pointing up.
3. Open your hand as wide as possible.
4. Line your hand up so that the glass is directly in front of your palm.
5. Slowly move your hand forward, keeping it about two inches above the table, until your palm touches the glass and stop.
6. Close your hand around the glass and stop when there is slight pressure.
7. Bring your thumb around the glass, opposite the closed fingers.
8. Keep your hand closed with slight, continued pressure, and raise your hand about three inches.
9. Bend the elbow of the arm that is holding the glass until it is at 90 degrees.
10. Lift the hand holding the glass until the top of the glass is in line with your bottom lip.
11. Bend the elbow of the arm that is holding the glass until the glass touches your bottom lip.
12. Open your mouth about a centimeter.
13. Keeping the glass in contact with your lip, rotate your hand slowly so that the thumb is moving down until water begins to flow into your mouth.
14. Once your mouth is half-full of water, rotate your hand in the opposite direction until the glass is up-right, and close your mouth.

History and Uses of Robots

ALT 3: Examining Robotic History through Writing

Summary:

Students will demonstrate, through writing, knowledge of the history of robots and infer the impact robots have had on society.

Competencies:

Upon completion of this lesson, students will be able to:

1. Recall facts from a passage on robotic history.
2. Explain how the use of robots has changed over the years.
3. Infer how robots have impacted society.
4. Form conclusions on whether the impact of robots on our society has been positive or negative.

Time:

Approximately five hours, including revision and final drafts.

Materials:

- Written passage discussing the history of robotics (photocopy ALT 3: Handout One) and rubric.

Instructions:

1. Students will take turns reading aloud from the passage about the history of robotics.
2. Discuss main ideas of the passage.
3. Individually, students will then make an information web for each of the following:
   - How the uses of robots have changed over the years,
   - How robots have impacted our society, and
   - The student's opinion of whether robots have positively or negatively impacted our society.
4. Each student will write a total of three paragraphs, one for each of the above webs.

Evaluation/Assessment of Student Competency:

Each of the three written paragraphs will be assessed using the rubric on page 13.

Closure:

Discuss reasons why certain types of robots have had greater effects on society than others.

1. What was it about the design or makeup of these robots that made them useful? Why can't robots solve unexpected problems?

2. What is "sequencing"?

3. How are a robot and an android different?

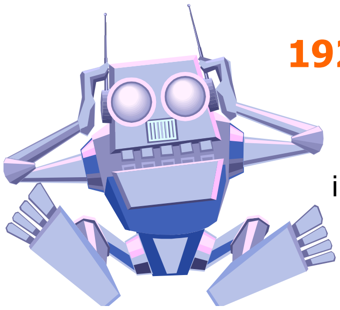
Extended writing and project ideas available from NASA JSC ROVer Ranch at http://prime.jsc.nasa.gov/ROV/projects.html

Have students do on-line research on "what is a robot" at the ROVer Ranch: http://prime.jsc.nasa.gov/ROV/traits.html

Suggested Reading:

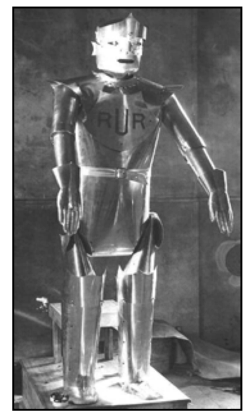
- *I, Robot* by Isaac Asimov
- *2001: A Space Odyssey* by Arthur C. Clarke
- *Hitchhiker's Guide to the Galaxy* by Doug Adams
- *Gateway* by Frederick Pohl
- *Do Androids Dream of Electric Sheep?* by Phillip K. Dick

The History of Robotics



1920

The idea of a robot is not new. For many years humans have imagined intelligent mechanical devices that perform human-like tasks. Inventors have designed and built automatic toys and equipment and imagined robots in drawings, books, plays and science fiction movies. In fact, the term “robot” was first used in 1920 in a play called “R.U.R.,” or “Rossum's Universal Robots,” by the Czech writer Karel Capek (pronounced “chop'ek”). The plot was simple: man makes robot then robot kills man! Many movies that followed continued to show robots as harmful, threatening machines.



More recent movies, like the 1977 film “Star Wars,” represent robots such as “C3PO” and “R2D2” as man's helpers. “Number Five” in the movie “Short Circuit” and C3PO actually take on a human appearance. Robots which are made to look human are called **androids**. The word **robot** comes from the Czech word *robota*, meaning “forced labor.”

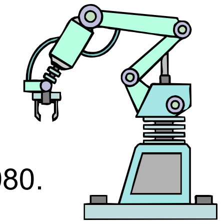
1941

In 1941, science fiction writer Isaac Asimov first used the word **robotics** to describe the technology of robots. He also predicted the rise of a powerful robot industry. If you look at our world today you can see that his prediction has come true! In recent years there has been explosive growth in the development and use of **industrial robots**. Terms like *robot revolution*, *robot age*, *and robot era* are now commonly used to describe this development. Robotics has become an accepted word used to describe all technologies associated with robots.

1956

In 1956, George Devil and Joseph Engelberger formed the world's first robot company. Devil predicted that industrial robots would “help the factory operator in a way that can be compared to business machines as an aid to the office worker.”

A few years later, in 1961, the very first industrial robot was "employed" in a General Motors automobile factory in New Jersey. Industrial robots have been used in many non-automotive industries since 1980. Advancements in electronics and computers made these modern-day robots possible.



Today

Fully-functioning androids are many years away. Problems still exist that must be solved. Yet, real, working robots are in use today, and they are changing the workplace! These robots do not look like androids. They are industrial workers, and they are actually computer-controlled "arms and hands." Industrial robots look so different from the popular image that the average person might not be able to recognize one!

Pros and Cons of Robots

Will robots *replace* humans? It is a good question, but the fact is that we are very far from having a robot with enough skills, intelligence and independence to replace human

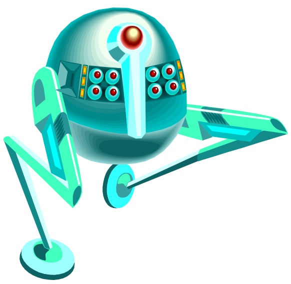
beings at the majority of tasks and chores. The robots that exist today are industrial models, not androids. And we can't really refer to them as "intelligent". Robots only do what we tell them to do. They can reproduce movements that imitate humans, such as holding, releasing, touching, pulling, and so on, but it is very difficult to make a robot that can *think*. Scientists and robotics engineers are working on creating robots with **artificial intelligence** (AI), but making a true, thinking robot that can learn from it's mistakes is still many years away.

Still, robots that imitate human movements can be very helpful, especially on an automobile assembly line or in an electronic printed circuits plant. Many **repetitive motions** and **exact processes** must take place to manufacture these items. Here, the robots perform well *... until something goes wrong*!

Industrial robots must be **programmed** ahead of time to perform a **sequence** of movements. That is how robots build things and do work. The objects they work on must remain in an exact, pre-specified position the whole time!

If an object gets out of position, or something goes wrong with the program, disaster follows. Industrial robots, with rare exceptions, are not smart! They do not have the senses of vision, touch or hearing. They do not know how to "feel" the object, or solve an unexpected problem. They do not have the ability to adapt to new situations on their own.

Robots offer specific benefits to workers, industries and countries. Industrial robots can improve **the quality of life** by freeing workers from dirty, boring, heavy and dangerous labor. It is true that robots can cause unemployment by replacing human workers, but robots also create jobs: robot technicians, salesmen, engineers, programmers and supervisors. Robots can benefit industry by improving the quality of the products they make, and by making it easier for management to plan how many products they can make per day. Industrial robots never complain and can work tirelessly night and day on an assembly line without a loss in performance. Therefore, they can greatly reduce the costs of manufactured goods. As a result of these benefits, countries that effectively use robots in their industries have an economic advantage on world market.



History of Robotics Rubric

	Beginning 0	Developing 1	Accomplished 2	Exemplary 3	Score
Organization	-No topic sentence -Several unrelated ideas -No ending -No sense of audience or purpose	-Weak topic sentence -Some unrelated ideas -Weak ending -Weak sense of audience or purpose	-Adequate topic sentence -Most ideas related to topic -Good ending -Some sense of audience and purpose	-States topic clearly -All ideas relate to topic -Contains clear ending -Considers audience and purpose	
Development	-No details to support topic -Lacks clear organization and pattern -Details not in order -No mention of information from internet, book, or magazine research	-Few details to support topic -Has some organization and pattern -Few details are mentioned from internet, book, or magazine research	-Some specific details to support topic -Rarely strays from order and pattern -Some specific details are mentioned from internet, book, or magazine research	-Many specific details to support topic -Follows logical order -Follows a consistent pattern of organization -Many specific details are mentioned from internet, book, or magazine research	
Structure	-No sentence variety -Many awkward sentences -Frequent fragments and run-ons -Lack of consistent point of view	-Limited sentence variety -Some awkward sentences -Some fragments and run-ons -Some shifts in point of view	-Some variety of sentences -Occasional awkward structure -Few fragments and run-ons -Few shifts in point of view	-Uses complete sentences -Uses great variety of sentence structure -Keeps the same point of view	
Mechanics	-Numerous errors	-Some errors in mechanics, grammar, and/or spelling.	-Generally uses mechanics, grammar, and spelling correctly	-Consistently uses mechanics, grammar, and spelling correctly	

Components of Robots

ALT 1: Physics and Robotics

Summary:

Students will demonstrate an understanding of the relationship among the following terms: mass, force, work, power, torque, and energy, and how they relate to robotics.

Competencies:

Upon completion of this lesson, students will be able to:

1. Apply knowledge of vocabulary terms (mass, force, work, power, torque, and energy) to robots.
2. Physically demonstrate an example of a given vocabulary term.
3. Propose a relationship among the above terms.

Time:

Approximately three hours

Materials:

- Photocopies of ALT 1: Handouts One through Six, found on the following pages.

Instructions:

1. Divide the class into 6 groups. Assign a topic to each group (mass, torque, power, energy, work, force). Give each group a different sheet to read and discuss. Students will make notes of the main idea and important details. (Do not answer printed questions at this time.) Groups will then select a spokesperson to relay their findings to the rest of the class.
2. As group spokespersons present their topics, the rest of the groups take notes on the important things mentioned. Stress the 6 concepts (mass, torque, power, energy, work, force) in your introduction of the groups.
3. Discuss, as a class, the total findings of all groups. Make connections between terms and, as part of the class discussion, go back and answer the printed questions that go with each section.
4. Students discuss with their group members how the topics and vocabulary terms relate to the field of robotics. (Recall video from previous day.) Each student will then write a paragraph discussing this relationship and the correlation to the topics.

Evaluation/Assessment of Student Competency:

Each group's grade will be based on several factors, as detailed in the Physics and Robotics Rubric on page 15.

Closure:

Discuss the activity, in which students will be asked to use the scientific method to design their own robot. They should keep in mind factors affecting the ability of their robots to function well. For example, how would mass affect the power?

Have students further research the components of robot systems at the ROVer Ranch: http://prime.jsc.nasa.gov/ROV/systems.html

Vocabulary words to be aware of:

acceleration	compress	elevation	exert	fluctuate
lug nut	rotate	saga	speed	subatomic

Physics and Robotics Rubric

	Beginning 0	Developing 1	Accomplished 2	Exemplary 3	Score
Working as part of a group	Student does not attempt to be a part of the group and/or hinders progress	Student does attempt to be a part of the group but is not an active member	Student is an active part of the group and fulfills given role	Student is an active part of the group, fulfills given role, and provides leadership	
Note Taking	Student does not take any notes	Student does not take notes for each speaker, and/or notes are sloppy and incoherent	Student takes detailed notes for each speaker, but notes lack some coherence	Student takes very detailed notes for each speaker, and the notes are neat and coherent	
Diagram	Student does not make a diagram	Student attempts to make a diagram, but connections among terms are missing and/or diagram is not neat	Student makes a neat diagram with few connections among terms missing	Student makes a high quality diagram with no connections among terms missing	
Paragraph	Student does not write a paragraph	Student attempts to write a paragraph, but lacks coherence	Student writes a paragraph that attempts to find relationships between vocabulary terms and robotics	Student writes a coherent paragraph that shows clear relationships between vocabulary terms and robotics	

What is Mass?

Common Units of Mass
SI:
Gram (g)
1 g = 0.001 kg
Kilogram (kg)
1 kg = 2.2 lbm
1 kg = 0.0685 slug

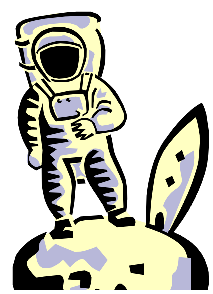
Generally, **mass is defined as the measure of *how much matter* an object or body contains**: it is the total number of subatomic particles (electrons, protons and neutrons) in the object. If you multiply your mass by the pull of Earth's gravity, you get your weight. (**W**eight = **m**ass x **g**ravity) So, if your body weight is fluctuating, by eating or exercising, it is actually the number of atoms in your body that is changing.

<u>The SI (Standard International) unit of mass is the gram (g) or kilogram (kg)</u>.

Earth's gravity = 1

Big Idea!!!

Your **mass** is not affected by where you are in space! You could be anywhere, on any planet, and your mass would still be the same!



The moon's gravity = 1/6

Gravity, on the other hand, does change. For example, the Earth's gravitational pull decreases as you move farther away from the Earth. Therefore, you can lose weight by changing your elevation, but your mass remains the same. You can also lose weight by living on the moon, but your mass is still the same. Your mass on earth is 50 kilograms. What is your mass on the moon?

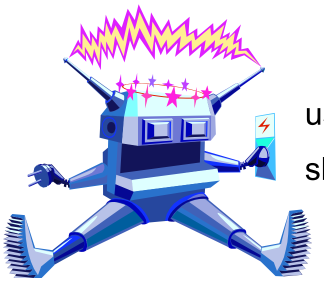
Answer: ____________________

Why?____

When we apply a force to something, it moves! Mass is important for calculating how fast things accelerate (change speed) when we apply a force to them. What determines how fast a car can speed up? You probably know that your car accelerates slower if it has five adults in it than if it only has one.

Why?____

What is Mass?

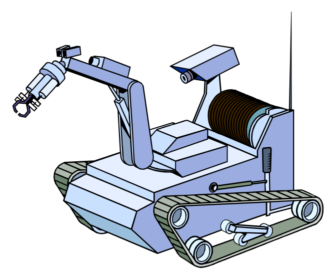


Think of a very simple demonstration of mass that you can do using just the things you have with you today. You will be asked to show your demonstration to the class during the class discussion.

Questions to answer in our class discussion later on:

1. How does the mass of a robot affect the amount of power a robot would need?

2. How does the mass of a robot affect the amount of force needed to move it? To move or pick up another object?



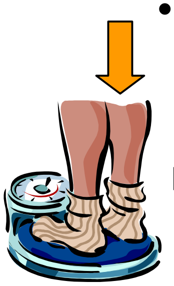
What is Force?

Common Units of Force

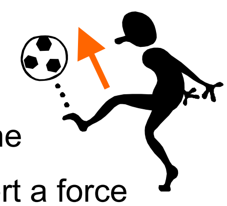
SI:
newton (N)
1 N = 0.225 lb
English:
Pound (lb)
1 lb = 4.448 N

One type of **force** that everyone is familiar with is **gravity**. Gravity is a force that the earth exerts on you. There are two interesting things about this force:

- It pulls you down, or, more exactly, towards the center of the earth.
- If you have more mass, the earth exerts a greater force on you.



When you step on the bathroom scale, you exert a force on the scale. Gravity pulls you down! The force you apply to the scale **compresses** a spring, which moves the needle on the dial.

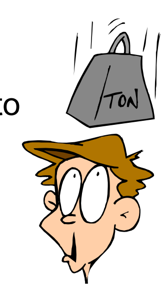


There are other kinds of forces! When you throw a baseball, you apply a force to the ball, which makes it speed up. An airplane engine creates a force, which pushes the plane through the air. A car's tires exert a force on the ground, which pushes the car along. You get the idea!

Force causes **acceleration**. If you apply a force to a toy car (for example, by pushing on it with your hand), it will start to move. This may sound simple, but it is a very important fact. The car moves because of **Isaac Newton's Second Law of Motion**. Newton's Second Law states that the *acceleration (**a**) of an object is directly proportional to the force (**F**) applied, and inversely proportional to the object's mass (**m**)*. That is, the more force you apply to an object, the faster it moves; and the more mass the object has, the more force needed to move it. To honor Newton's achievement, the standard unit of force in the SI (Standard International) system was named the **newton**.

Isaac Newton

$F = ma$
$a = F/m$



If you drop an object, it falls! The Earth exerts enough force to accelerate objects that are dropped at a rate of **9.8 m/s^2** (meters per second squared).

So after the first second, it will be traveling at 9.8 meters per second. After 2 seconds it will be traveling at 19.6 meters per second.

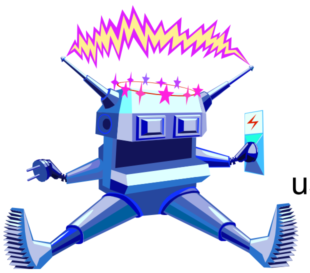
How fast will it be traveling after 5 seconds? **Use the formula $v = at$ to find out!**

V velocity = **a** (the acceleration due to gravity - 9.8 m/s^2) x **t** (the time in seconds - 5 seconds) that it falls.

If a car moved this fast it would reach 60 mph (miles per hour) in less than 3 seconds!

The force of gravity can make things move pretty fast! It is a very strong force!

Acceleration due to gravity is:
9.8 m/s^2 or
32 ft/s^2



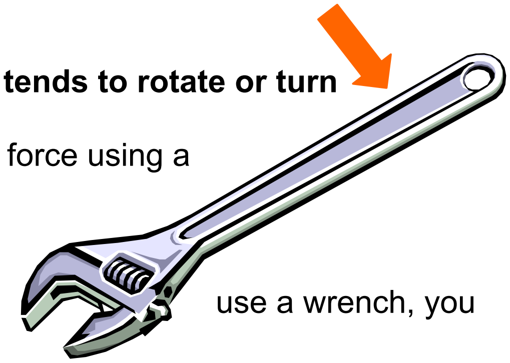
Think of a very simple demonstration of force that you can do using just the things you have with you today. You will be asked to show your demonstration to the class during class discussion.

Questions to answer in our class discussion later on:

1. How would the amount of force needed to accelerate your robot be affected by its mass?

2. How does Newton's Second Law apply to the field of robotics? (Be specific!)

What is Torque?



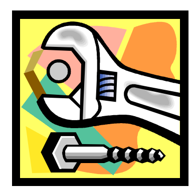
Torque (pronounced “tork”) **is a force that tends to rotate or turn things**. You generate torque any time you apply a force using a wrench. Tightening the lug nuts on the wheels of your car is a good example of torque. When you use a wrench, you apply a force to the handle. This force creates a torque, which turns the lug nut. The SI (Standard International) unit of torque is the Newton-meter.

Common Units of Torque

SI:
Newton meter (Nm)
1 Nm = 0.737 ft lb

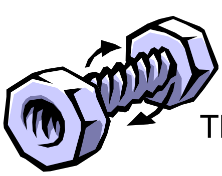
Notice that the **unit of measurement** for torque contains a distance (meter) and a force (Newton). To calculate the torque needed to turn something, multiply the *force* by the *distance from the center* of the thing you are trying to turn.

Torque = force x distance

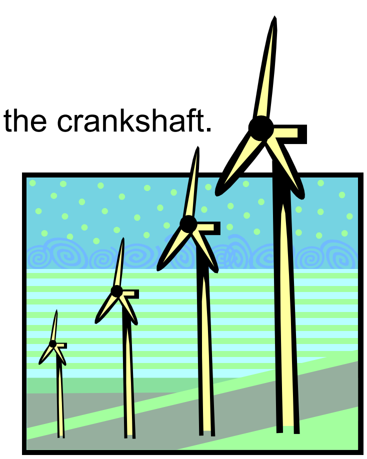


In the case of the lug nuts, if the wrench is 0.3 m long, and you put 50 N of force on it, you are generating 15 Newton-meters of torque (50 N x 0.3 m = 15 Nm) to turn the lug nuts.

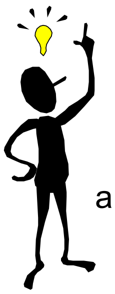
If you use a 0.6 m long wrench, you only need to put 25 Newtons of force on it to generate the same torque (25 N x 0.6 m = 15 Nm). \



A car engine creates torque, and uses it to spin the crankshaft. This torque is created exactly the same way; a force is applied to a rod which spins the shaft.



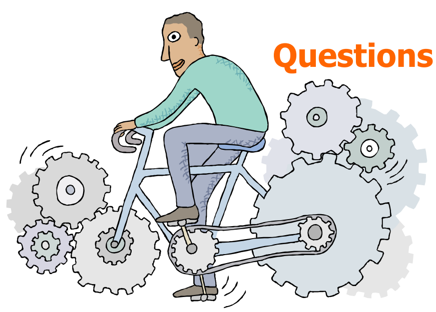
Wind creates torque which makes things spin.



Have you have ever tried to loosen a really tight nut on a bolt? If you have, then you know a good way to make a lot of torque is to position the wrench so that it is horizontal, and then push down on the end of the wrench. This way you are applying all of your weight at a distance equal to the full length of the wrench.

If you were to position the wrench with the handle pointing straight up, and then push on the top of the handle - assuming you could keep your balance - you would have no chance of loosening the nut. You might as well push down directly on the nut.

Think of a very simple demonstration of torque that you can do using just the things you have with you today. You will be asked to show your demonstration to the class during the class discussion.



Questions to answer in our class discussion later on:

1. How would the size of the gears change the torque needed to turn them?

2. What gear combination would require the most force (torque) to turn them? Which combination would require the least?

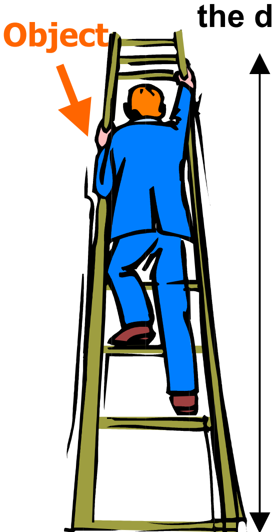
3. How does the gear combination affect the amount of <u>power</u> needed for your robot?

What is Work?

No… not homework, or chores! The work we are talking about here is good old mechanical work.

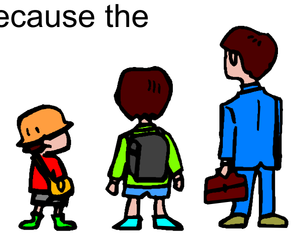
Work is simply the application of a force over a distance, with one catch -- the distance only counts if it is in the direction of the force you apply.

Work = Force x distance…
but the motion has to be in the same direction as the force!



Lifting a weight from the ground and putting it on a shelf is a good example of work. The force is equal to the weight of the object, and the distance is equal to the height of the shelf. (The force and the motion are going in the same direction.)

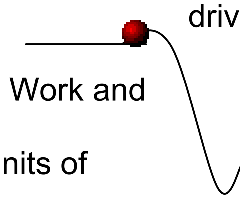
If you stand still with a heavy backpack on your back, you have not done any work on the backpack. It may have felt like you did work, because the backpack was heavy. But… because there was no motion no work was being done on the backpack.



Your car also does work. When it is moving it applies a force to counter the forces of friction and wind drag.

If it drives up a hill, it does the same kind of work that you do when lifting a weight. When it drives back down the hill, however, it gets back the work it did. The hill helps the car move down.

Work is energy that has been used. When you do work, you use energy. But sometimes the energy you use can be recovered. When the car drives up the hill, the work it does to get to the top helps it get back down. Work and energy are closely related. The units of work are the same as the units of energy, which we will discuss later.



Think of a very simple demonstration of work that you can do using just the things you have with you today. You will be asked to show your demonstration to the class during the class discussion.

Questions to answer in our class discussion later on:

1. How does work relate to energy?

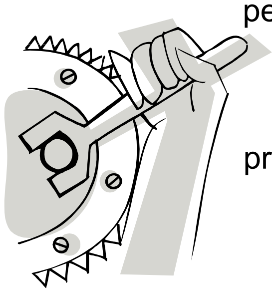
2. What kind of tasks could a robot do that require it to do work?

3. Where does a robot get the energy to do work?

4. How does work relate to power?

What is Power?

Power is a measure of how fast work can be done. Using a lever you may be able to make something spin around, but could you spin that lever around 3,000 times per minute? That is exactly what your car engine does! Machines are capable of making much more power than our bodies alone could provide.



The *amount of force* you use to push down on the lever is called **torque** (pronounced "tork"). How *fast* you can turn the lever is called **power**.

The SI (Standard International) unit for power is the **watt**. In order to find the power (watts) needed to turn a wheel, multiply the amount of force (torque) by how fast you want the wheel to turn.

Power is speed (m/s) times force (N).

If you were pushing on something with a force of 1 N, and it moved at a speed of 1 m/s, your power output would be 1 watt.

One watt is equal to one Newton-meter per second (N-m/s).

Common Units of Power

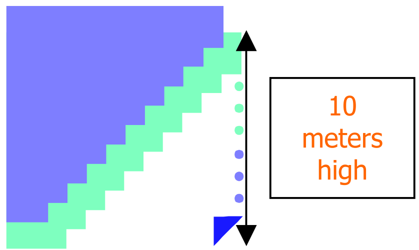
SI:
Watts (W)
1000 W = 1 kW
Kilowatt (kW)
1 kW = 1.341 hp
English
Horsepower (hp)
1 hp = 0.746 kW

How much power can you make?

An interesting way to **figure out how much power** you can generate is to see how fast you can run up a flight of stairs.

1. Measure the height of a set of stairs that takes you up about three stories.
2. Time yourself while you run up the stairs as quickly as possible.
3. Divide the height of the stairs by the time it took you to ascend them. This will give you your speed.
4. Use your speed to find the power.

Try it!



If it takes you 15 seconds to run up 10 meters, then your speed was 0.66 m/s (only your speed in the vertical direction is important).

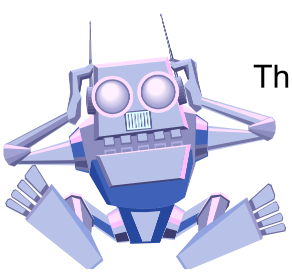
10/15 = 0.66 (your speed)

So **how much force** did you exerted over those 10 meters? Since the only thing you hauled up the stairs was yourself, the force is equal to your weight.

Now find **the amount of power you generated.** Multiply your weight by your speed. How much power would be needed to travel up the stairs at a speed of 0.50 m/s if your weight (force) was 125 pounds?

Answer: ____ (show work!)

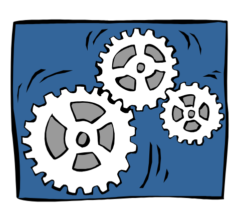
power = (height of stairs / Time to climb) x weight



Think of a very simple demonstration of power that you can do using just the things you have with you today. You will be asked to show your demonstration to the class during the class discussion.

Questions to answer in our class discussion later on:

1. How does power relate to the torque of your robot?
2. How does power relate to force?
3. How does power relate to the mass of your robot?
4. How could you find the power output of your robot?
5. How could power relate to gears?



What is Energy?

Common Units of Energy

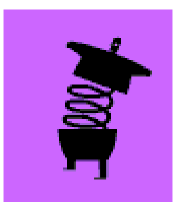
SI:
Newton meter (Nm)
1 Nm = 1 J
1 J = 0.239 cal
1 cal = 4.184 J
1 Wh = 3,600 J
1 kWh = 1000 Wh
1 kWh = 3,600,000 J

Wow! Energy is tough! If power is like the strength of a weightlifter, then energy is like his endurance. Energy is like the fuel used to make power!

Energy is a measure of how long we can sustain the output of power, or how much work we can do. One common unit of energy is the **kilowatt-hour** (kW-hr). A kW is a unit of measuring power. If we are using one kW of power, a kW-hr of energy will last one hour. If we use 10 kW of power, we will use up the kW-hr in just six minutes.

There are two kinds of energy: **potential** and **kinetic**.

Potential Energy



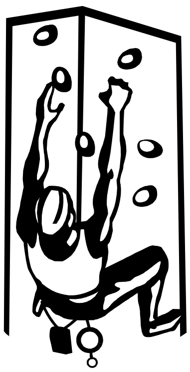
Potential energy is energy that is waiting to be converted into power. It is stored energy. Gasoline in a fuel tank, food in your stomach, a compressed spring, and a weight hanging from a tree are all examples of potential energy.

The human body is a type of energy conversion device. It converts food (fuel) into power, which can be used to do work. A car engine converts gasoline (fuel) into power, which can also be used to do work. Gasoline and food are stored *chemical energy*.

A pendulum clock is a device that uses the energy stored in hanging weights to do work. Springs inside the clock store *mechanical energy* which is then used by the weights.

When you lift an object higher off the ground it gains potential energy. The higher you lift it, and the heavier it is, the more energy it gains. The stored energy from these next examples comes from gravity.

If you lift a bowling ball one inch, and drop it on the roof of your car, it won't do much damage (please, don't try this) because it doesn't have much energy. But if you lift the ball 100 feet and drop it on your car, it will put a huge dent in the roof. The same ball dropped from a higher height has even more energy. So, by increasing the height of an object, you increase its potential energy.



The formula to calculate the potential energy (PE) you gain when you increase your height is:

PE = Force x Distance

Kinetic Energy

Kinetic energy is energy of motion. Objects that are moving, such as a rollercoaster, make kinetic energy (KE). If a car crashes into a wall at 5 mph, it shouldn't do too much damage to the car. But if it hits the wall at 40 mph, the car will most likely be totaled. Kinetic energy is similar to potential energy, but the energy is not stored. The more the object weighs, and the faster it is moving, the more kinetic energy it has.

Think of a very simple demonstration of energy that you can do using just the things you have with you today. You will be asked to show your demonstration to the class during the class discussion.

Questions to answer in our class discussion later on:

1. How does energy relate to the tasks you want your robot to do?
2. When does your robot need the most power?
3. Where is the potential energy of your robot? Where is the kinetic energy?

Physics and Robotics Rubric

	Beginning 0	Developing 1	Accomplished 2	Exemplary 3	Score
Working as part of a group	Student does not attempt to be a part of the group, and/or hinders progress	Student does attempt to be a part of the group, but is not an active member	Student is an active part of the group, and fulfills given role	Student is an active part of the group, fulfills given role, and provides leadership	
Note taking	Student does not take any notes	Student does not take notes for each speaker, and/or notes are sloppy and incoherent	Student takes detailed notes for each speaker, but notes lack some coherence	Student takes very detailed notes for each speaker, and the notes are neat and coherent	
Diagram	Student does not make a diagram	Student attempts to make a diagram, but connections among terms are missing and/or diagram is not neat	Student makes a neat diagram with few connections among terms missing	Student makes a high quality diagram with no connections among terms missing	
Paragraph	Student does not write a paragraph	Student attempts to write a paragraph, but lacks coherence	Student writes a paragraph that attempts to find relationships between vocabulary terms and robotics	Student writes a coherent paragraph that shows clear relationships between vocabulary terms and robotics	

Components of Robots

ALT 2: Robot Programming

Summary:

Students will discover that robots need sensors to help them perform most tasks, and will be introduced to the different kinds of robotic sensors generally used. Students will learn to use distance formulas and ratios to program a robot to move a certain distance.

Competencies:

Upon completion of this lesson, students will be able to:

1. Identify different robot sensors, and what they do.
2. Manipulate distance formulas to find rate, time, and distance of a moving object.
3. Use distance formulas and rates to find the amount of time necessary for a robot to move specific distances.

Time:

Approximately six hours

Materials:

- Teacher example of a MindStorms robot
- An obstacle course for the MindStorms robot
- A stop watch or watch with a second hand
- A measuring tape
- Student activity worksheet
- Rubric

Instructions:

1. Set up the obstacle course for the MindStorms robot, and tell the class what you expect the robot to be able to accomplish on the course. (An example of a possible obstacle course is on Handout One of this ALT.) The course may be made from items available in the classroom, such as books, desks, boxes, rulers, etc.
2. The class will give the teacher specific, oral instructions, while the teacher. manually moves the robot through the maze following the students' directions exactly.
3. Timing is important when the robot tries to maneuver the course. Ask the class, "How will the robot know when to execute each command?"
4. Explain to the students that the robot must have some kind of sensor to know when to perform each command. Discuss what a sensor is. (Sensors detect changes in the environment. The robot reacts when the environment around it changes.) What does a sensor do? Do humans have sensors?

5. Describe to the students the most common types of sensors and what they do:
    - **Touch** – “Feels” objects around it. When the sensor is pushed in, the robot knows to execute a specific command.
    - **Light/Color** – “Sees” different color values. When the amount of light reflected from different colors (wavelengths) changes, the sensors detects the change. The robot’s program tells it to execute a specific command when this happens.
    - **Temperature** – “Feels” a change in temperature. The robot’s program tells it to execute a specific command when this happens.
    - **Sound** – “Hears” specific wavelengths. The robot’s program tells it to execute a specific command when the wavelength changes.
6. In groups, have students write directions for the obstacle course. This time, they must incorporate sensors into the directions. The students must include 3 out of the 4 sensors described in class in their instructions. They must also include “comments” written in parentheses that describe how the sensors are used to control the robot.
7. Explain to the class that an alternative way to program the robot to go through the obstacle course would be to use distance as an indicator. You can program the robot to move a certain distance before it performs a command, (ex: go three feet, then turn 45 degrees to the right.). Brainstorm with the class – What are some different ways the robot could use to sense the amount of distance covered?
8. Show the class the formula: **Rate x Time = Distance**. Depending on grade level, you may have to explain that we can use this formula to solve for the missing time value when the other two values (rate and distance) are known. We will need to know how long it takes the robot to go a certain distance. **Note:** The robot will move slower as the batteries wear down. Make sure you use fresh batteries.
9. Use number sentences to explain how to use the formula. Show number sentences of basic facts the students know (2 + ? = 5). Ask the students what the missing number is. Ask the students, “How could you find what that missing number is if you did not know?” Explain that would subtract 2 from 5. Further explain that you are doing the opposite operation that is show to find the missing value. Have the class do a number of examples solving addition and subtraction problems
10. Repeat the process for multiplication and division problems.
11. Using a robot, students will record how long it takes the robot to go 10 feet. Put the values into the formula **Rate x Time = Distance**, and find the robot’s rate of speed. Use that rate to decide long it would take the robot to move 2 feet, 5 feet, 15 feet, 20 feet.
12. With teacher guidance, have students complete the problem solving worksheet using the distance formula.

Evaluation/Assessment of Student Competency:

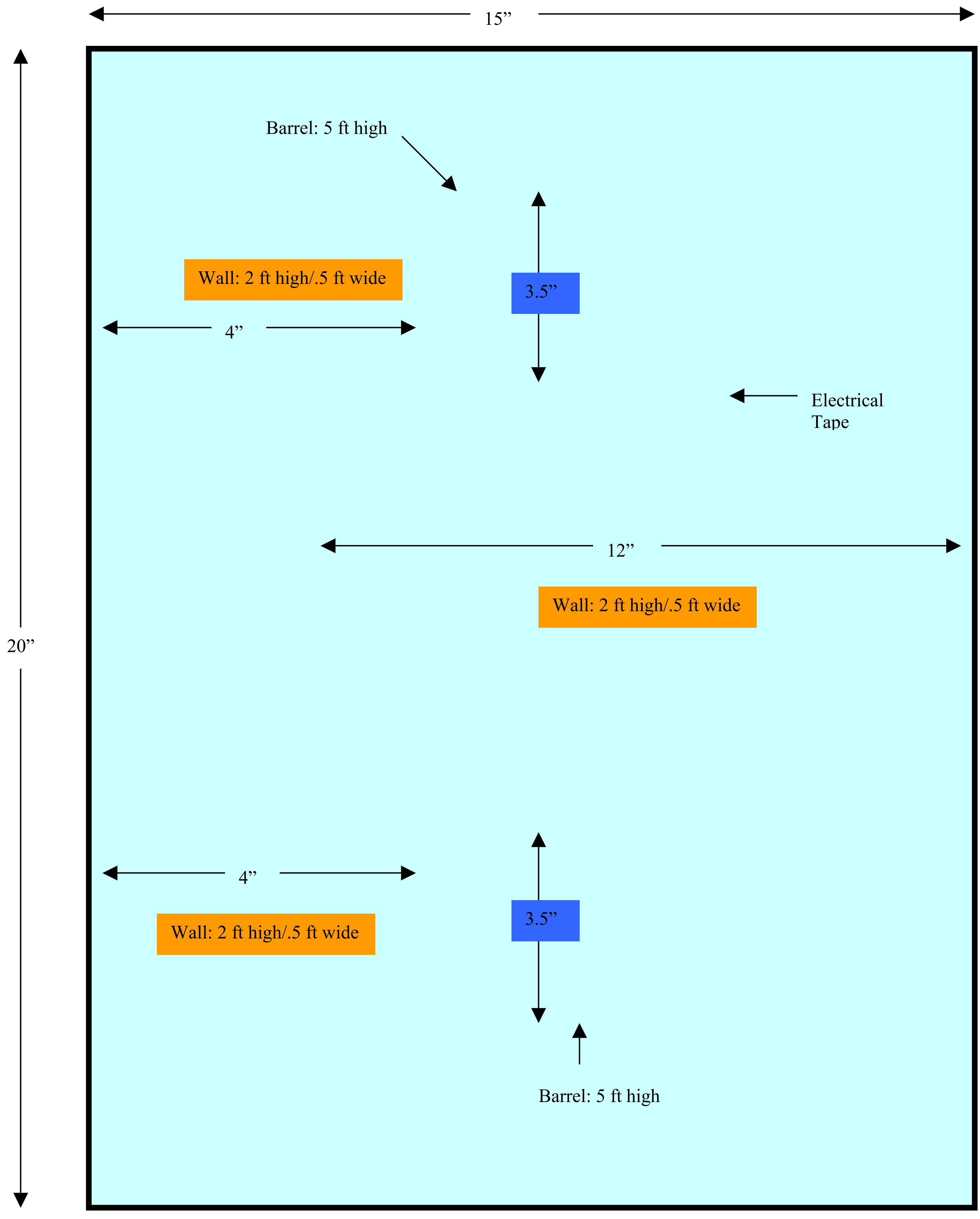
Student assessment for writing the obstacle course directions, (step 6) will be based on criteria found in the rubric on student handout three (pg 44). Student assessment for the problem solving worksheet is also explained on the handout.

Closure:

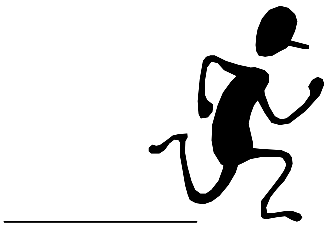
1. Discuss with students how the power of a robot relates to the rate of speed and the distance it travels.
2. Talk about whether changing the gear combination but keeping the same power will then alter the rate it travels. How does this work?
3. Have students take the ROVer Ranch Vocabulary fun quiz from NASA on-line: http://prime.jsc.nasa.gov/ROV/vocab.html
4. Have students conduct further research on the components of robot systems at the ROVer Ranch: http://prime.jsc.nasa.gov/ROV/systems.html

Sample Obstacle Course

This is an example of an obstacle course. It can be modified to your specific needs.



Using Rate of Speed to Find the Distance Covered



Rate x Time = Distance

R x T = D

For each example, use the distance formula to solve for the missing value. (One point for substituting in the correct numbers, and one point for solving correctly.)

1. R = 5 km/hr
   T = 12 hr
   D = ? km
2. R = ? ft/sec.
   T = 18 sec.
   D = 90 ft
3. R = 27 m/min.
   T = ? min.
   D = 432 m
4. R = ? mi/hr
   T = 3 hr
   D = 200 mi
5. R = 650 mi/hr
   T = 3 hr
   D = ? mi
6. R = 98 in/sec.
   T = ? sec.
   D = 9800 in.

Use the distance formula to solve each problem. Make sure to write out the formula and show all the steps needed to solve each problem.

7. A robot needs to stop one foot in front of a wall that is 5 feet away. How many seconds must the robot be going forward before it must stop, if it is moving at a rate of .2 ft/sec.?
8. How far can a robot travel if it is moving at a rate of 4ft/min. and is running for 10 minutes?
9. Our robot needs to be programmed to complete an obstacle course in less than 8 minutes. What is the minimum speed the robot can travel if the course is a total of 56 feet long?
10. Our robot needs to go forward ten feet, stop, turn 180 degrees, and return from its starting place. If it's rate is 2 ft/sec., and it takes one second to stop and 3 seconds to turn around, how long will the task take?

(Answer Key)

Using Rate of Speed to Find the Distance Covered

Rate x Time = Distance R x T = D

For each example, use the distance formula above to solve for the missing value. (One point for substituting in the correct numbers, and one point for solving correctly.)

1. R x T = D
   5 x 12 = D
   60 = D
   Distance is 60 km.

2. R x T = D
   R x 18 = 90
   R = 90/18
   R = 5
   Rate is 5 ft/sec.

3. R x T = D
   27 x T = 432
   T = 432/27
   T = 16
   Time is 16 min.

4. R x T = D
   R x 3 = 200
   R = 200/3
   R = 6.67
   Rate is 6.67 mi/hr.

5. R x T = D
   650 x 3 = D
   1950 = D
   Distance is 1950 mi.

6. R x T = D
   98 x T = 9800
   T = 9800/98
   T = 100
   Time is 100 sec.

Use the distance formula to solve each problem. Make sure to write out the formula and show all the steps needed to solve each problem. Be sure to answer your questions in complete sentences. (One point for substituting in the correct numbers, one point for solving the equation correctly, and one point for the correct final answer.)

7. R * T = D
   .2 * T = 4
   T = 4/.2
   T = 20
   The robot would need to travel for 20 seconds before stopping.

8. R * T = D
   4 * 10 = D
   40 = D
   The robot could travel 40 feet.

9. R * T = D
   R * 8 = 56
   R = 56/8
   R = 7
   The robot must travel 7 ft/min.

10. R * T = D
    2 * 10 = D
    20 = D
    20 + 3 + 1 = 24
    The task will take 24 seconds.

Obstacle Course Instructions Rubric

	Beginning 4	Developing 6	Accomplished 8	Exemplary 10	Score
Written Directions	-Many steps were omitted -Did not include any sensors	-Some steps omitted -Only included one or two kinds of sensors	-Included the necessary steps -Included three different kinds of sensors	-Included the necessary steps -Directions were very clear and descriptive -Included four different types of sensors	

Components of Robots

ALT 3: Critical Thinking: What Makes a "Good" Robot?

Summary:

Students will use knowledge of robotic components as discussed in Section One, ALT 1 to write a detailed description of the robot they want to design.

Competencies:

Upon completion of this lesson, students will be able to:

1. Explain clearly what components are found in "good," robots - ones that do the programmed job well.
2. Begin designing a robot whose goal is to accomplish a certain task specified by the student.

Time:

Approximately three hours, including revision and rewrite.

Materials:

- Student - created brainstorming web to be used for prewriting.

Instructions:

1. As a class, discuss the characteristics that make a well-designed robot versus a poorly designed robot. (See Teacher Information Sheet for details.)
2. Students will make a prewriting web that visually shows their ideas. The teacher must approve students' webs before they continue on to the writing portion of the lesson.
3. After teacher approval, students begin their writing. One paragraph should be made for each of the following:
   - Discuss various components of robots, and give examples of what can be accomplished with those components. What makes a robot well-designed? Efficient?
   - Tell what task you want your robot to be able to do, and what components need to be included in order to meet that goal. Briefly describe some of the features you want your robot to have (how large, what shape, what manner of locomotion). Describe the amount of power, torque, and energy your robot will need.

Evaluation/Assessment of Student Competency:

Both paragraphs will be assessed using the rubric provided with this lesson.

Closure:

1. Discuss the importance of making a plan before beginning a project.

2. Connect this idea to the design of the robots, and stress the significance of evaluating the final result as well.
3. Discuss the process of re-evaluating the robot after each design step, and redesigning those parts that can be done more efficiently.

What Makes a "Good" Robot" Rubric

	Beginning 0	Developing 1	Accomplished 2	Exemplary 3	Score
Organization	-No topic sentence -Several unrelated ideas -No ending -No sense of audience or purpose	-Weak topic sentence -Some unrelated ideas -Weak ending -Weak sense of audience or purpose	-Adequate topic sentence -Most ideas related to topic -Good ending -Some sense of audience and purpose	-States topic clearly -All ideas relate to topic -Contains clear ending -Considers audience and purpose	
Development	-No details to support topic -Lacks clear organization and pattern -Details not in order	-Few details to support topic -Has some organization and pattern	-Some specific details to support topic -Rarely strays from order and pattern	-Many specific details to support topic -Follows logical order -Follows a consistent pattern of organization	
Structure	-No sentence variety -Many awkward sentences -Frequent fragments and run-ons -Lack of consistent point of view	-Limited sentence variety -Some awkward sentences -Some fragments and run-ons -Some shifts in point of view	-Some variety of sentences -Occasional awkward structure -Few fragments and run-ons -Few shifts in point of view	-Uses complete sentences -Uses great variety of sentence structure -Keeps the same point of view	
Mechanics	-Numerous errors	-Some errors in mechanics, grammar, and/or spelling.	-Generally uses mechanics, grammar, and spelling correctly	-Consistently uses mechanics, grammar, and spelling correctly	

'Good' Versus 'Bad' Robot Design
Ideas for Efficient Design

+ Interchangeable attachments
    - faster response time

+ User-friendly
    - controls
    - gives feedback
    - orientation (inside/outside)

+ Artificial Intelligence (AI)
    - one command does many functions

+ Modular
    - can add parts as you go so it can be updated

+ Reliable

+ Task-appropriate

+ Efficient
    - power
    - time
    - programming

+ Type of interface
    - robot-robot
    - human-robot
    - machine-robot

+ External appearance
    - does it "look good" for the prescribed user?

+ Gear usage/ratio

+ Waterproof, if needed

+ Way to sense that object to be picked up is in range

+ Size is appropriate

+ Power is in areas that need it

+ Locomotion
    - terrain appropriate

Design of Robots

ALT 1: Robot designing using the Scientific Method

Summary:

Students will apply knowledge of the process of the scientific method as they design a new type of robot using a writing done in language arts class as the basis for their design.

Competencies:

Upon completion of this lesson, students will be able to:

1. Understand the five steps in the Scientific Method, as it relates to designing and testing models of robots.
2. Make conclusions and alterations to their model, based on data.

Time:

Approximately three hours

Materials:

- Photocopies of ALT 1: Handouts One and Two, found on the following pages.

Instructions:

1. Introduce the Scientific Method using a simple example.
2. Give students copies of the Scientific Method handout on the following page.
3. Divide class into groups of six, if possible. These will be the robot building teams. Each team will be responsible for creating a design for a working robot based on a writing done in language arts.
4. Student teams will use the first three steps of the Scientific Method to write notes on what task they want their robot to do, what components their robot needs to have, and how they want the robot to look. They will then put those notes into paragraph form.

Evaluation/Assessment of Student Competency:

Assessment will be based on groups' adherence to the steps of the Scientific Method. (See rubric found on ALT One: Handout Two.)

Closure:

1. Talk about using the last two steps of the Scientific Method during the transfer activity. These last two steps will be used when students actually build and program a robot.
2. Discuss with students the importance of strictly adhering to the steps of the Scientific Method throughout the transfer activity. It is a tool that will make this experimentation process easier.

The Scientific Method

Design of Robots ALT 1: Handout One

STEP 1: State the Problem	**You cannot solve a problem until you know what it is.** My problem is: I need to build a robot to accomplish my mission. What does the robot need to be able to do?
Step 2: Research the Problem	**Figure out what it will take to solve my problem?** What do I know, and need to know, about my problem? To solve my problem, I need to know how to build and program a robot. • Examine the possibilities • Eliminate poor choices • Consider likely sources
Step 3: Form a Hypothesis	**A hypothesis is a possible solution to my problem.** Remember: The simplest solution is often the best solution! Based on my research, I will build and program a robot that can (state the goals… what task(s) will be done?).
Step 4: Test the Hypothesis	**Perform an experiment to see if your possible solution is a valid one.** To test my hypothesis I will program my robot and try it!
Step 5: Draw conclusions from the data	**Look at the results of the experiment.** There are only two possibilities: • The robot was successful, so your hypothesis was correct. Problem solved! • The robot did not work properly, so your hypothesis needs to be revised. **Don't Give Up! Do More Research!** • What was wrong with the original hypothesis? • Was the robot able to do the job? • Was the programming at fault? • Was your experiment flawed? • Form another hypothesis based on more research and do the test again! **In other words, go back to Step 3!**

Continue this Process Until You Solve The Problem!

Robot Design/Scientific Method Rubric

	Beginning 0	Developing 1	Accomplished 2	Exemplary 3	Score
Designing the Experiment	Fails to develop any type of plan	Design allows comparison of variables to standard	Design allows comparison of variables, but lacks sufficient number of tests to obtain meaningful data	Design allows comparison of variables and indicates sufficient number of tests to obtain meaningful data	
Collecting and Reporting Data	Fails to collect any data	Describes observations in rambling discourse	Makes a meaningful table, but fails to record the observations or records them inaccurately	Makes a meaningful table and records the data accurately and neatly	
Drawing Conclusions	Fails to reach a conclusion	Draws a conclusion that is not supported by the data	Draws a conclusion that is supported by the data, but fails to show the support for the conclusion	Draws a conclusion that is supported by the data, and gives supporting evidence for the conclusion	

Design of Robots

ALT 2: Robot Design Sketch

Summary:

Students will make a drawn-to-scale mechanical drawing of their robot using the concepts of similar figures, proportion and scale.

Competencies:

Upon completion of this lesson, the students will be able to:

1. Draw a scale design of a robot using the concept of proportions.

Time:

Approximately five hours

Materials:

- Pencil, paper, rulers, protractor, compass, rubric

Instructions:

1. Have students draw a model of their robot. They must include the actual, life-size finished measurements for their desired robot design. The drawing can include more than one view: ex: front, back, and side.
2. Based on the actual measurements, students will calculate the measurements needed for their scale drawings by using proportions.
   - Students will pick a ratio to use to convert the life-size measures to the drawn-to-scale measures (Ex: 1 foot = 1 inch). The ratio will then be used to write a proportion to find the scale measurements. (See next page - A teacher example of this initial drawing and measurements are found on Handout Two of this lesson.)
   - If necessary, have students do a number of practice problems involving proportions before they perform the calculations for their projects.
3. Students will make a new drawn-to-scale drawing of their robot using rulers and the scale measurements from their calculations.

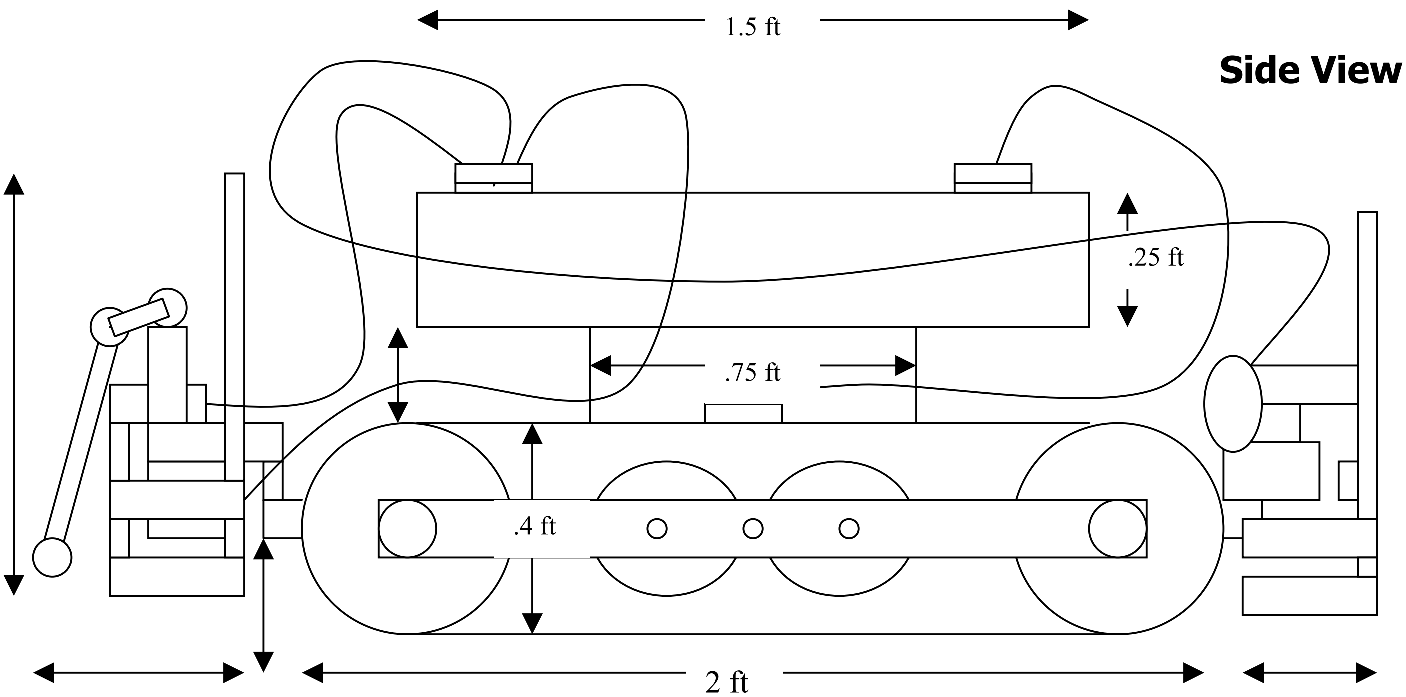
Evaluation/Assessment of Student Competency:

Student assessment will be based on criteria found in the rubric on the student handouts.

Closure:

1. Share with students the goal of the transfer activity. Let them know that they will need to be able to take their knowledge of robot construction and put it into use as they build and program a real, working Lego® robot.

Teacher Example of Initial Robot Drawing Using Full-Scale Measurements



1. Choose a ratio to use for the new, drawn-to-scale design for the robot.

Ratio: 2 in = 1 ft

2. Use that ratio to write a proportion for each piece in the drawing.
Cross multiply to solve.
The piece of our real robot that we want to be 2 ft long needs to be drawn 4 in long.
Do this for all of the measurements of the robot.

$$\frac{2 \text{ in}}{1 \text{ ft}} = \frac{X \text{ in}}{2 \text{ ft}}$$

$$X = 2 \times 2$$

$$X = 4 \text{ in}$$

3. The final drawing should be drawn-to-scale using a ruler.

*** Note: in the above drawing, not all needed measures have been included.**

Robot Design Sketch Rubric

	Beginning 0	Developing 1	Accomplished 2	Exemplary 3	Score
Initial Sketch	-sketch is sloppy -includes only a few of the life-size measures that are needed	-sketch is fairly neat -includes most life-size measurements that are needed	-sketch is neatly drawn -includes at least one view -includes all life-size measures that are needed	-sketch is drawn neatly -includes more than one view -includes all life-size measures	
Scale Measurements	-correctly wrote a proportion comparing one life-size measure with one scale measure -used proportions to find few of the scale measures for of the drawing	-correctly wrote a proportion comparing one life-size measure with one scale measure -used proportions to find scale measures for some of the drawing	-correctly wrote a proportion comparing one life-size measure with one scale measure -used proportions to find scale measures for most of the drawing	-correctly wrote a proportion comparing one life-size measure with one scale measure -used proportions to find scale measures for all of the drawing	
Scale Drawing	-drawing is sloppy -includes few needed measures -parts of the design are not drawn to scale	-drawing is fairly neat -includes most needed measurements -some parts of the design are drawn to scale	-drawing is neat -includes all needed measurements -most parts of the design are drawn to scale	-drawing is very neat -includes all needed measures -all parts of the design are drawn to scale	

Design of Robots

ALT 3: Was your Robot a "Good" Robot?

Summary:

Students will evaluate, through writing, the design of their robots.

Competencies:

Upon completion of this lesson, students will be able to:

1. Draw conclusions about which robotic components are useful in certain situations, and which are not.
2. Evaluate the effectiveness and efficiency of their design.

Time:

Approximately five hours, including rewrite and revision

Materials:

- Scientific method data sheet from science class showing the steps to follow when designing the robots.
- Paper and writing utensil

Instructions:

1. Ask students to think about the design of their robot. Have students write a paragraph discussing three good points and three not-so-good points of their design.
2. Have students write a paragraph that discusses what components enabled them to achieve the task they set for the robot, or what parts hindered them from doing so.
3. Have students write a third paragraph discussing what, if anything, would they change about the design to make it more efficient.

Evaluation/Assessment of Student Competency:

The three written paragraphs will be assessed using the rubric for this lesson.

Closure:

1. Discuss with students the importance of a good design, and orally recall the various robot components and their functions. Let them know that this knowledge will be invaluable to them as they move into the final transfer activity.

Rubric
Was your Robot a "Good" Robot?

	Beginning 0	Developing 1	Accomplished 2	Exemplary 3	Score
Organization	-No topic sentence -Several unrelated ideas -No ending -No sense of audience or purpose	-Weak topic sentence -Some unrelated ideas -Weak ending -Weak sense of audience or purpose	-Adequate topic sentence -Most ideas related to topic -Good ending -Some sense of audience and purpose	-States topic clearly -All ideas relate to topic -Contains clear ending -Considers audience and purpose	
Development	-No details to support topic -Lacks clear organization and pattern -Details not in order	-Few details to support topic -Has some organization and pattern	-Some specific details to support topic -Rarely strays from order and pattern	-Many specific details to support topic -Follows logical order -Follows a consistent pattern of organization	
Structure	-No sentence variety -Many awkward sentences -Frequent fragments and run-ons -Lack of consistent point of view	-Limited sentence variety -Some awkward sentences -Some fragments and run-ons -Some shifts in point of view	-Some variety of sentences -Occasional awkward structure -Few fragments and run-ons -Few shifts in point of view	-Uses complete sentences -Uses great variety of sentence structure -Keeps the same point of view	
Mechanics	-Numerous errors	-Some errors in mechanics, grammar, and/or spelling.	-Generally uses mechanics, grammar, and spelling correctly	-Consistently uses mechanics, grammar, and spelling correctly	

Transfer Activity

Upon conclusion of this unit, students should see how the ideas they have studied and learned connect to the real world. To extend this application to hands-on activities, teachers are invited to do the transfer activity that follows.

As previously mentioned, many companies produce robot kits, one of which is the MindStorms Invention System. This transfer activity involves the use of this product to expand upon the material learned throughout the unit.

First, students will actually build and program their own robot. (We recommend that students follow the tutorial that is included in the kit when building their robots.) It is through this exploration that the students will learn how to get their robots to perform certain tasks.

Next, teachers should set up a series of challenges for the robots to complete. It is very important that students are only told information that is critical to the challenge; in other words, tell them as little as possible. Students learn best by experimenting and inventing with their own solutions to challenges rather than being told how to accomplish the task at hand. They should be encouraged to experiment and make modifications as needed (remember the Scientific Method!), and stress that it is NOT a competition - all who meet the challenge have been successful.

US FIRST (For Inspiration and Recognition of Science and Technology) sponsors various competitions during the year which are open to teams of students. Teams are comprised of eight to ten students. Each team needs an adult sponsor. To get more information on these competitions, go to www.usfirst.org. These competitions foster teamwork and creative thinking, and enhance logic and sequencing skills.

Appendix One: Robot Resources

Internet resources:

These sites contain excellent information, photos, and links to other sites. Some sites also contain short video clips, lesson plans, and ideas for tying robotics into your curriculum.

http://prime.jsc.nasa.gov/ROV/library.html
www.firstlegoleague.org
www.howstuffworks.com
www.kipr.org/curriculum/content.html
www.kipr.org/curriculum/curriculum_intro.html
http://tc.engr.wisc.edu/zwickel/Outreach/robotics.html
www.unt.edu/robotics/reference.htm
http://ranier.hq.nasa.gov/telerobotics_page/coolrobots.html
http://www.ai.mit.edu/projects/humanoid-robotics-group/cog/cog.html
http://avdil.gtri.gatech.edu/AUVS/IARCLaunchPoint.html
http://www.pbs.org/safarchive/4_class/45_pguides/pguide_705/4575_idx.html
http://cache.ucr.edu/~currie/roboadam.htm

Speaker/ Informational resources:

To arrange for robot mentors or guest instructors for your class, contact the WPAFB Educational Outreach Office at (937) 904-8622 or email educational.outreach@wpafb.af.mil .

Other resources:

There are a number of videos on robotics for sale on the PBS and NOVA websites.

There are wonderful robotic kits available for purchase. (The MindStorms Robotic Invention System is an excellent example.) These would be great tools for students to use as they design their own robots.

Many professional organizations support using robotics in the classroom, and provide mini-grants for teachers to purchase robot kits. These organizations include the American Institute Aeronautics and Astronautics (AIAA), the Ohio Space Grant Consortium (OSGC), the American Society of Mechanical Engineers (ASME) and the Civil Air Patrol (CAP). Links to their grant application pages are given below.

www.aiaa.org/education/index2.cfm?edu=19
www.osgc.org/page/Minigrant.html
www.asme.org/educate.k12
www.wpafb.af.mil/cap/glr-ae/forms/grants.htm

Competitions:

US FIRST (For Inspiration and Recognition of Science and Technology) sponsors various robotics competitions during the year which are open to teams of students. Teams are comprised of eight to ten students. Each team needs an adult sponsor. To get more information on these competitions, go to www.usfirst.org. These competitions foster teamwork and creative thinking, and enhance logic and sequencing skills.

For more information about robots, kits, and competitions, please call the Wright Patterson Air Force Base Educational Outreach Office at (937) 904-8622 or email Educational.Outreach@wpafb.af.mil

Appendix Two: Gear Basics

Gears are wheels with teeth. Gears mesh together and make things turn.
Gears are used to transfer motion or power from one moving part to another.
Gears increase or decrease the power or speed, but you cannot increase both at the same time.
The gear attached to the motor is called the *primary gear* or *driver gear*. The motor turns this gear and it makes the second gear turn in the opposite direction.
The second gear is called the *secondary gear or follower gear.*
The *speed* of a gear is number of revolutions it makes per minute (rpm).
The diameter of the gears has a lot to do with the speed of the gear and the amount of *force* needed to turn the gears.The force is called *torque*.
Reducing the number of revolutions is called *gear reduction* (high torque). Increasing the number of revolutions is called *gearing up* (high speed).
Gear ratios are used to increase the force or speed. The gear ratio is the [number of turns of the driver]**:**[number of turns of the follower].   Example   2:1

Student Investigative Activity:

Build a set of gears as shown below using a 24 tooth and 40 tooth gear. Put an axle through the both gears and attach it to a support beam. Use a marker to make a small line on the side of each gear so you can count the number of times each gear completes one full revolution.

You will use the large gear as the driver gear. Use the axle to turn the large gear to the right.

1. Which way does the small gear turn?
2. Does the follower gear turn faster or slower than the primary gear?

Use the small gear as it as your driver gear. Use the axle to turn it to the right.

1. Which way does the large gear turn?
2. Does the follower gear turn faster or slower than the primary gear?

Gear Speed:

Use the mark on the side of the gears to help you find the gear speed. Use the large gear as the driver and count how many times the follower gear turns when you turn the driver one full revolution.

Driver makes 1 turn and the follower makes ______ turns. The gear ratio is 1:____.

Switch and make the small gear the driver. Now what is the gear ratio.

Driver makes 1 turn and the follower makes ______ turns. The gear ratio is 1:____.

Concept Question: Which took more force to turn, the large gear or the small gear? Try stopping it with your hand. Which took more force (torque)? Which ratio gives more power? More speed?

Extension: Add more gears and repeat the investigation with three gears. Try it with a different gear combination.