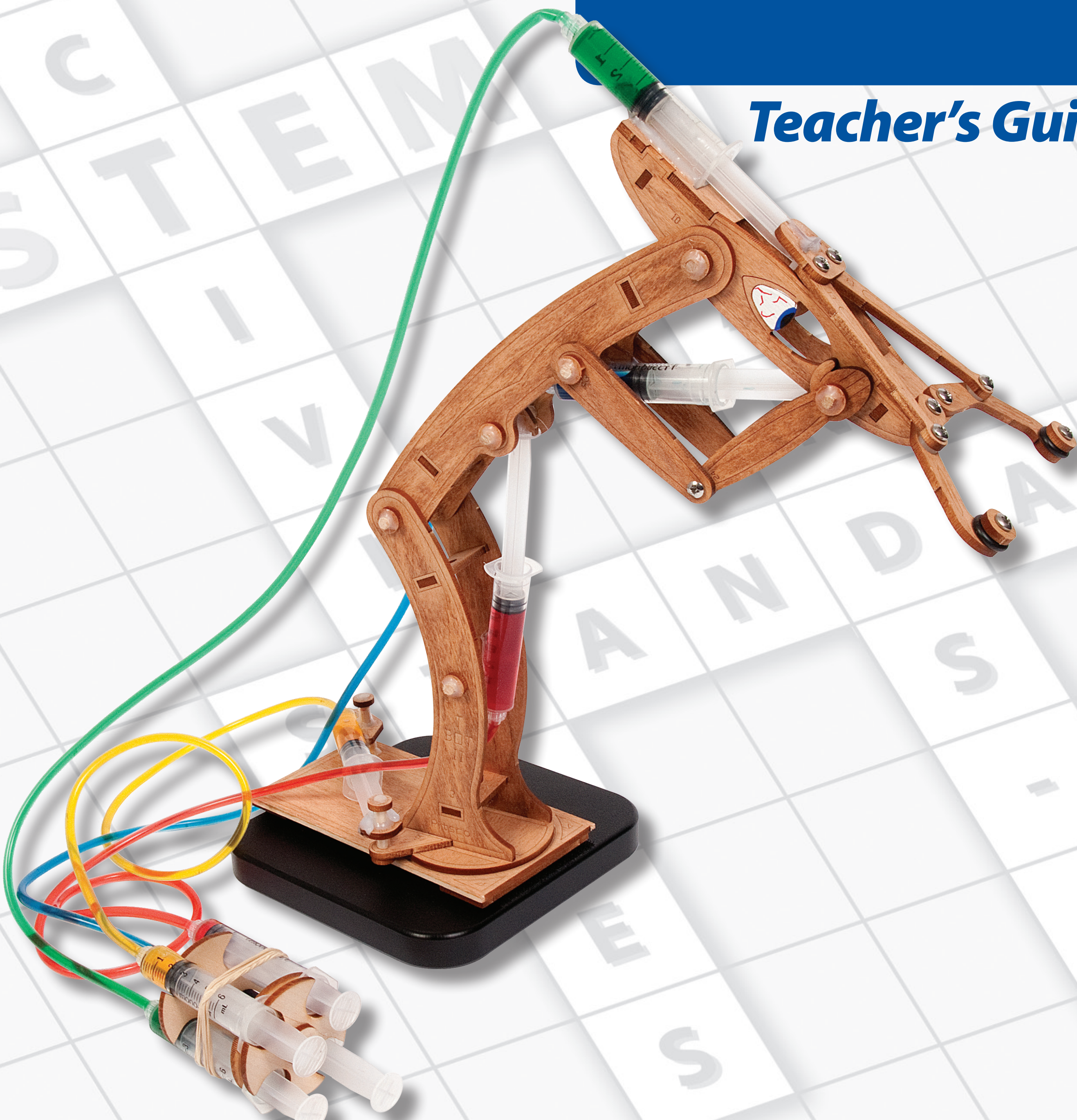
# T-Bot® II

## *Teacher's Guide*



**STEM** Curriculum for T-Bot® II

PITSCO EDUCATION

59727
V0608

Written by Tim Cannell.

Content advising by Bill Holden and Dana Cochran.

Cover and document design by Rod Dutton.

Graphics by Todd McGeorge and Ben Gaddy.



ISBN: 1-58651-926-3

# Table of Contents

# Activity Overview

Using the provided kit materials, students construct the T-Bot® II.

The *T-Bot II Getting Started Teacher's Guide* contains both basic and advanced lesson plans. Basic lesson plans provide a more guided approach to instruction, while advanced lesson plans are more open-ended. All lesson plans can be used to extend students' understanding of science, technology, engineering, and math concepts using the T-Bot II.

Resource materials are provided to supplement students' understanding of core content. Resources include vocabulary, puzzles, assessments, and content fact sheets.

# Standards Addressed by Activity

Standards were taken from the International Technology and Engineering Educators Association (ITEEA), the National Council of Teachers of Mathematics (NCTM), the National Science Teachers Association (NSTA), and the National Council of Teachers of English (NCTE).

## Cartesian Coordinate System

NSTA 5-8
Students develop abilities necessary to do scientific inquiry.

- Students identify questions that can be answered through scientific investigations.
- Students use appropriate tools and techniques to gather, analyze, and interpret data.
- Students think critically and logically to make the relationships between evidence and explanations.
- Students communicate scientific procedures and explanations.
- Students use mathematics in all aspects of scientific inquiry.

Students develop abilities for technological design.

- Students evaluate completed technological designs or products.

NCTM 6-8
Students specify locations and describe spatial relationships using coordinate geometry and other representational systems.

- Students use coordinate geometry to represent and examine the properties of geometric shapes.

Students build new mathematical knowledge through problem solving.

Students apply and adapt a variety of appropriate strategies to solve problems.

Students use visualization, spatial reasoning, and geometric modeling to solve problems.

- Students recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.

Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students understand both metric and customary systems of measurement.

ITEEA 6-8
Students develop the abilities to assess the impact of products and systems.

- Students learn to design and use instruments to gather data.

Students develop the abilities to apply the design process.

- Students learn to apply a design process to solve problems in and beyond the laboratory-classroom.
- Students learn to make a product or system and document the solution.

## Program Instruction Set

NSTA 5-8
Students develop abilities necessary to do scientific inquiry.

- Students identify questions that can be answered through scientific investigations.
- Students use appropriate tools and techniques to gather, analyze, and interpret data.
- Students think critically and logically to make the relationships between evidence and explanations.
- Students communicate scientific procedures and explanations.

Students develop abilities for technological design.

- Students communicate the process of technological design.

NCTM 6-8
Students apply appropriate techniques, tools, and formulas to determine measurements.

- Students select and apply techniques and tools to accurately find length, area, volume, and angle measures to appropriate levels or precision.

Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students understand, select, and use units of appropriate size and type to measure angles, perimeter, area, surface area, and volume.

ITEEA 6-8
Students develop an understanding of the influence of technology on history.

- Students learn that the design and construction of structures for service or convenience have evolved from the development techniques for measurement, controlling systems, and the understanding of spatial relationship.

Students develop an understanding of the attributes of design.

- Students learn that design is a creative planning process that leads to useful products and systems.
- Students learn that there is no perfect design.

Students develop an understanding of engineering design.

- Students learn that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

## Simple Machine Identification

NSTA 5-8
Students develop abilities necessary to do scientific inquiry.

- Students identify questions that can be answered through scientific investigations.
- Students use appropriate tools and techniques to gather, analyze, and interpret data.
- Students think critically and logically to make the relationships between evidence and explanations.
- Students recognize and analyze alternative explanations and predictions.

- Students communicate scientific procedures and explanations.
- Students use mathematics in all aspects of scientific inquiry.

Students develop understandings about scientific inquiry.

- Students understand different kinds of questions suggest different kinds of scientific investigations and some investigations involve observing and describing objects, organisms, or events, some involve collecting specimens, some involve experiments, some involve seeking more information, some involve discovery of new objects and phenomena, and some involve making models.

ITEEA 6-9

Students develop an understanding of the influence of technology on history.

- Students learn that the design and construction of structures for service or convenience have evolved from the development techniques for measurement, controlling systems, and the understanding of spatial relationship.

Students develop an understanding of the attributes of design.

- Students learn that design is a creative planning process that leads to useful products and systems.
- Students learn that there is no perfect design.

Students develop an understanding of engineering design.

- Students learn that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

NCTM 6-8

Students recognize and apply mathematics in contexts outside of mathematics.

## Engineering Challenge I

NSTA 5-8

Students develop abilities necessary to do scientific inquiry.

- Students identify questions that can be answered through scientific investigations.
- Students use appropriate tools and techniques to gather, analyze, and interpret data.
- Students think critically and logically to make the relationships between evidence and explanations.
- Students recognize and analyze alternative explanations and predictions.
- Students communicate scientific procedures and explanations.
- Students use mathematics in all aspects of scientific inquiry.

Students develop understandings about scientific inquiry.

- Students understand different kinds of questions suggest different kinds of scientific investigations and some investigations involve observing and describing objects, organisms, or events, some involve collecting specimens, some involve experiments, some involve seeking more information, some involve discovery of new objects and phenomena, and some involve making models.

Students develop abilities for technological design.

- Students evaluate completed technological designs or products.

NCTM 6-8
Students recognize and apply mathematics in contexts outside of mathematics.

ITEEA 6-8
Students develop an understanding of engineering design.

- Students learn that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

Students develop the abilities to apply the design process.

- Students learn to apply a design process to solve problems in and beyond the laboratory-classroom.
- Students learn to make a product or system and document the solution.

Students develop the abilities to assess the impact of products and systems.

- Students learn to design and use instruments to gather data.

NCTE K-12
Students adjust their use of spoken, written and visual language to communicate effectively with a variety of audiences and for different purposes.

## Work Envelope

NSTA 9-12
Students develop the abilities to do scientific inquiry.

- Students identify questions and concepts that guide scientific investigations.
- Students design and conduct scientific investigations.
- Students use technology and mathematics to improve investigations and communications.
- Students formulate and revise scientific explanations and models using logic and evidence.
- Students communicate and defend a scientific argument.

NCTM 9-12
Students compute fluently and make reasonable estimates.

- Students judge the reasonableness of numerical computations and their results.

Students use mathematical models to represent and understand quantitative relationships.

- Students draw reasonable conclusions about a situation being modeled.

Students understand measurement attributes of objects and the units, systems, and processes of measurement.

- Students make decisions about units and scales that are appropriate for problem situations involving measurement.

Students recognize and use connections among mathematical ideas.

- Students recognize and apply mathematics in contexts outside of mathematics.

Students understand meanings of operations and how they relate to one another.

- Students judge the effects of such operations as multiplication, division, and computing powers and roots on the magnitudes on quantities.

Students understand patterns, relations, and functions.

- Students interpret representations of functions of two variables.

# Standards Addressed

Students represent and analyze mathematical situations and structures using algebraic symbols.

- Students understand the meaning of equivalent forms of expressions, equations, inequalities, and relations.
- Students use symbolic algebra to represent and explain mathematical relationships.

Students analyze characteristics and properties of two- and three-dimensional shapes and develop mathematical arguments about geometric relationships.

- Students use trigonometric relationships to determine lengths and angle measures.

Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students make decisions about units and scales that are appropriate for problem situations involving measurement.

Students apply appropriate techniques, tools, and formulas to determine measurements.

- Students use unit analysis to check measurement computations.

Students build new mathematical knowledge through problem solving.

- Students solve problems that arise in mathematics and in other contexts.
- Students apply and adapt a variety of appropriate strategies to solve problems.
- Students monitor and reflect on the process of mathematical problem solving.

Students organize and consolidate their mathematical thinking through communication.

- Students communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
- Students use the language of mathematics to express mathematical ideas precisely.

Students recognize and use connections among mathematical ideas.

- Students recognize and apply mathematics in contexts outside of mathematics.

Students create and use representations to organize, record, and communicate mathematical ideas.

- Students select, apply, and translate among mathematical representations to solve problems.

ITEEA 9-12
Students develop an understanding of the attributes of design.

- Students learn design problems are rarely presented in a clearly defined form.
- Students learn that design needs to be continually checked and critiqued and the ideas of the design must be redefined and improved.

## Mechanical Advantage

NSTA 9-12
Students develop the abilities to do scientific inquiry.

- Students identify questions and concepts that guide scientific investigations.

- Students design and conduct scientific investigations.
- Students use technology and mathematics to improve investigations and communications.
- Students formulate and revise scientific explanations and models using logic and evidence.
- Students communicate and defend a scientific argument.

Students develop understandings about scientific inquiry.

- Students understand mathematics is essential in scientific inquiry and understand mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations, and communicating results.

Students understand motions and forces.

- Students understand objects change their motion only when a net force is applied; understand laws of motion are used to calculate precisely the effects of forces on the motion of objects; understand the magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of force; and understand whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

Students understand about science and technology.

- Students understand creativity, imagination, and a good knowledge base are all required in the work of science and engineering.

Students understand the nature of scientific knowledge.

- Students understand scientific explanations must meet certain criteria; understand first and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied; understand they should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public; and understand explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.

NCTM 9-12

Students compute fluently and make reasonable estimates.

- Students develop fluency in operations with real numbers, vectors, and matrices, using mental computation or paper-and-pencil calculations for simple cases and technology for more complicated cases.

Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students make decisions about units and scales that are appropriate for problem situations involving measurement.

# Standards Addressed

ITEEA 9-12
Students develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

- Students learn technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.
- Students learn technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.
- Students learn technological progress promotes the advancement of science and mathematics.

Students develop an understanding of engineering design.

- Students learn established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

# Modifying the End Effector

NSTA 9-12
Students develop the abilities to do scientific inquiry.

- Students identify questions and concepts that guide scientific investigations.
- Students design and conduct scientific investigations.
- Students use technology and mathematics to improve investigations and communications.
- Students formulate and revise scientific explanations and models using logic and evidence.
- Students communicate and defend a scientific argument.

NCTM 9-12
Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students make decisions about units and scales that are appropriate for problem situations involving measurement.

Students recognize and use connections among mathematical ideas.

- Students recognize and apply mathematics in contexts outside of mathematics.

ITEEA 9-12
Students develop an understanding of the attributes of design.

- Students learn design problems are rarely presented in a clearly defined form.
- Students learn that design needs to be continually checked and critiqued and the ideas of the design must be redefined and improved.

Students develop abilities to apply the design process.

- Students learn to develop and produce a product or system using a design process.
- Students learn to evaluate final solutions and communicate observations, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

NCTE K-12
Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes.

## Engineering Challenge II

NSTA 9-12
Students develop the abilities to do scientific inquiry.

- Students identify questions and concepts that guide scientific investigations.
- Students design and conduct scientific investigations.
- Students use technology and mathematics to improve investigations and communications.
- Students formulate and revise scientific explanations and models using logic and evidence.
- Students communicate and defend a scientific argument.

NCTM 9-12
Students compute fluently and make reasonable estimates.

- Students judge the reasonableness of numerical computations and their results.

Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students make decisions about units and scales that are appropriate for problem situations involving measurement.

Students recognize and use connections among mathematical ideas.

- Students recognize and apply mathematics in contexts outside of mathematics.

ITEEA 9-12
Students develop an understanding of the attributes of design.

- Students learn design problems are rarely presented in a clearly defined form.
- Students learn that design needs to be continually checked and critiqued and the ideas of the design must be redefined and improved.

Students develop abilities to apply the design process.

- Students learn to identify the design problem to solve and decide whether or not to address it.
- Students learn to evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.
- Students learn to develop and produce a product or system using a design process.
- Students learn to evaluate final solutions and communicate observations, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

# Standards Addressed

Students develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

- Students learn technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.

NCTE K-12
Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes.

# Construction QuickView

In this guide's activities, students will use white glue, cool-melt glue, and scissors to create a hydraulic robot arm made of basswood, syringes, tubing, and other materials.

More detailed construction information is included with the T-Bot® II kit materials.

# Teaching Tips

## Safety

Supervise students while the T-Bot® II is being constructed.

Before using, securely fasten the T-Bot II to a stable position using the hook-and-loop fasteners.

Provide proper supervision when students disconnect the syringes and hoses.

## Construction Tips/Helpful Hints

- Press and hold the pieces firmly when gluing to ensure a tight joint. A tight joint will prevent parts from breaking due to stress.
- Apply more glue to the joint if needed.
- Be sure to remove excess glue at joints before the glue dries.
- Sandpaper can be used to make minor adjustments to the fitting of the joints.
- Dry fit all pieces before gluing. This will enable you to see how the pieces are correctly positioned.
- When finished using the T-Bot II for the day, depress (or push) the plungers so each syringe is pushed down halfway. By leaving the syringes like this, pressure is less likely to allow air to seep into the syringes.

## Materials by Activity

Cartesian Coordinate System
- Completed Pitsco T-Bot II
- Graph paper
- Metric ruler
- Pencil
- Tape
- Pair of dice
- Small foam block
- Weight or C clamp
- “Coordinates” worksheet
- “Understanding the Cartesian Coordinate System” resource page

Program Instruction Set
- Completed Pitsco T-Bot II
- Small foam block
- Metric ruler
- Protractor
- Paper
- Pencil

Simple Machine Identification
- Completed Pitsco T-Bot II
- Pencil
- “Simple Machines” worksheet
- “Simple Machines” resource page

Engineering Challenge I
- Completed Pitsco T-Bot II
- Six small foam blocks
- Notebook/design logbook

Work Envelope
- Completed Pitsco T-Bot II
- Pencil
- Metric ruler
- “Work Envelope Data Sheet”
- Protractor

Mechanical Advantage
- Completed Pitsco T-Bot II
- Pencil
- "Calculating Mechanical Advantage" resource page
- "Mechanical Advantage" worksheet
- Metric ruler
- Two small foam blocks (varying in size)
- Calculator

Modifying the End Effector
- Completed Pitsco T-Bot II
- Battery-powered electromagnet with a switch (see "Electromagnet" resource page)
- Graph paper
- Pencil
- Zip ties
- Tape
- Hook-and-loop fastener
- Metric ruler
- Paper clips

Engineering Challenge II
- Pencil
- Paper
- Graph paper
- Multiple Pitsco T-Bot IIs
- Small foam blocks
- Designated work area

## Troubleshooting

It is likely that a little air will eventually get into the T-Bot II syringe units. A little air will not affect the function of the robot. However, if a lot of air gets into the lines, you should refill the syringes.

To do this, pull back the plunger on the control end of the syringe unit and carefully detach the tube from the syringe attached to the robot. Empty the control-end syringe and tube and then refill them just as you did when filling them for the first time.

If an axis is not properly working, it may be due to a kink or bend in the hose. If the hose will not return to its original shape and if the kink is not located near the end of the hose, you will need to replace the entire length of the hose. If the kink is located near an end, then remove the hose and cut the kink off. Return the hose to its original connection making certain there is enough fluid to operate the axis.

# QuickView

Students design a 6 x 6 grid based on the Cartesian coordinates. Students roll two dice to determine the coordinate points on the grid for a specific quadrant. Students use the T-Bot II to place a foam block onto the "rolled" grid point.

# Standards Addressed

NSTA 5-8
Students develop abilities necessary to do scientific inquiry.

- Students identify questions that can be answered through scientific investigations.
- Students use appropriate tools and techniques to gather, analyze, and interpret data.
- Students think critically and logically to make the relationships between evidence and explanations.
- Students communicate scientific procedures and explanations.
- Students use mathematics in all aspects of scientific inquiry.

Students develop abilities for technological design.

- Students evaluate completed technological designs or products.

NCTM 6-8
Students specify locations and describe spatial relationships using coordinate geometry and other representational systems.

- Students use coordinate geometry to represent and examine the properties of geometric shapes.

Students build new mathematical knowledge through problem solving.

Students apply and adapt a variety of appropriate strategies to solve problems.

Students use visualization, spatial reasoning, and geometric modeling to solve problems.

- Students recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.

Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students understand both metric and customary systems of measurement.

ITEEA 6-8
Students develop the abilities to assess the impact of products and systems.

- Students learn to design and use instruments to gather data.

Students develop the abilities to apply the design process.

- Students learn to apply a design process to solve problems in and beyond the laboratory-classroom.
- Students learn to make a product or system and document the solution.

# Time Required

45-90 minutes (will vary with class size)

# Content Areas

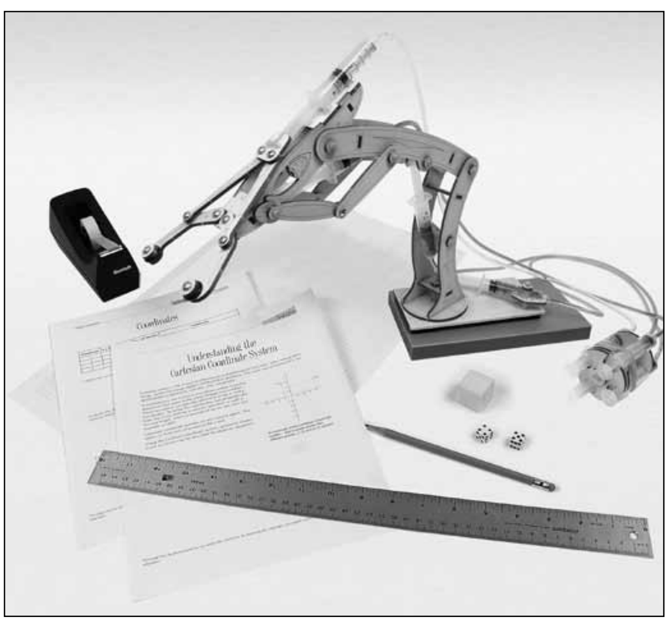
Primary: Math
Secondary: Science, language arts, technology

# Vocabulary

- Cartesian coordinate system
- coordinate
- intersection
- origin
- x-axis
- y-axis

# Materials

- Completed Pitsco T-Bot II
- Graph paper
- Metric ruler
- Pencil
- Tape
- Pair of dice
- Small foam block
- Weight or C clamp
- "Coordinates" worksheet
- "Understanding the Cartesian Coordinate System" resource page



# Procedure

1 Draw a two-plane coordinate system on a sheet of graph paper. The x-axis is horizontal and placed in the paper's middle and is parallel to the long edge of the graph paper. Label this line as the x-axis. Refer to the "Understanding the Cartesian Coordinate System" resource page for help.

*The x-axis line should be drawn the entire length of the paper and positioned on a graph line.*

2 The y-axis is placed in the paper's middle and is parallel to the short edge of the graph paper. Label this line as the y-axis.

*The y-axis line should be drawn the entire width of the paper and positioned on a graph line.*

3 The x and y intersection point will represent the origin. Label this point on the graph paper as zero (0).

4 Position the metric ruler so the end point of the ruler is aligned with the origin. The ruler is parallel to the x-axis.

5 Measure and mark six lines that are 1.9 centimeters apart from each other. Each of these lines is drawn on the x-axis line to the right of the origin. This will represent the positive side of the x-coordinate plane.

*If students are using 1/4" graph paper, then three squares are approximately equal to 1.9 cm.*

6 The first coordinate point to the right of the origin along the positive x-coordinate plane is labeled with the number 1. Label the remaining five coordinate points as follows: 2, 3, 4, 5, and 6.

7 Measure and mark six lines that are 1.9 centimeters apart from each other and are drawn on the x-axis line to the left of the origin. This will represent the negative side of the x-coordinate plane.

8 The first coordinate point to the left of the origin along the negative x-coordinate plane is labeled with the number -1. Label the remaining five coordinate points as follows: -2, -3, -4, -5, and -6.

9 Measure and mark six lines that are 1.9 centimeters apart from each other. Each of these lines is drawn on the y-axis line above the origin. This will represent the positive side of the y-coordinate plane.

10 The first coordinate point above the origin along the positive y-coordinate plane is labeled with the number 1. Label the remaining five coordinate points as follows: 2, 3, 4, 5, and 6.

11 Measure and mark six lines that are 1.9 centimeters apart from each other and are drawn on the y-axis line below the origin. This will represent the negative side of the y-coordinate plane.

12 The first coordinate point below the origin along the negative y-coordinate plane is labeled with the number -1. Label the remaining five coordinate points as follows: -2, -3, -4, -5, and -6.

13 Label the positive x and positive y quadrant as Quadrant 1.

14 Label the negative x and positive y quadrant as Quadrant 2.

15 Label the negative x and negative y quadrant as Quadrant 3.

16 Label the positive x and negative y quadrant as Quadrant 4).

17 Secure the T-Bot II to the work surface.

*The work surface needs to be large enough to accommodate the work envelope of the T-Bot II. Secure the T-Bot II with either a weight or some type of clamping device.*

18 Position the T-Bot II in the Home position. The Home position is the initial starting point of the T-Bot II and is identified by having all controller syringe plungers fully depressed.

19 Locate the graph paper in front of the T-Bot II. Secure the graph paper to the work surface with the use of tape.

*The graph paper should be placed in the middle of the T-Bot II range of motion for all axes.*

20 Place the small foam block onto the origin of the coordinate plane.

21 You will roll the pair of dice to determine where the foam block is to be placed. The first die rolled will represent a coordinate point on the x-axis, and the second die rolled will represent a coordinate point on the y-axis. The first roll of both dice (rolled one at a time) will represent coordinate points in Quadrant 1. The second roll of both dice (rolled one at a time) will be Quadrant 2 and so forth.

22 Roll the dice to determine the Quadrant 1 coordinates. Record these coordinates in the corresponding field of the "Coordinates" worksheet.

*An example recording of x-y coordinates might be (3,4). The x coordinate is always expressed first.*

23 Manipulate the T-Bot II to pick up the foam block and move it to the Quadrant 1 coordinates. Keep track of how many moves are required to place the foam block. Record the number of moves in the corresponding field of the "Coordinates" worksheet. Any movement of a controller syringe counts as a single move.

24 Record the results of the T-Bot II operation in the Comments column in the table on the "Coordinates" worksheet.

*Sample comments include whether they were successful or unsuccessful in placing the foam block and if the coordinates were outside of the work envelope.*

25 Repeat these steps to complete a T-Bot II operation for each of the Quadrants listed on the "Coordinates" worksheet.

A. Start the T-Bot II in the Home position.

B. Place the foam block onto the origin.

C. Roll the dice to determine the coordinates for the specified quadrant.

D. Manipulate the T-Bot II to move the foam block to the determined coordinates.

E. Complete the "Coordinates" worksheet as you finish the T-Bot II operation.

26 Answer the questions located on the "Coordinates" worksheet.

# QuickView

Design a 6 x 6 grid based on the Cartesian coordinates. Roll two dice to determine the coordinate points on the grid for a specific quadrant. Use the T-Bot II to place a foam block onto the “rolled” grid point.

# Materials

- Completed Pitsco T-Bot II
- Graph paper
- Metric ruler
- Pencil
- Tape
- Pair of dice
- Small foam block
- Weight or C clamp
- “Coordinates” worksheet
- “Understanding the Cartesian Coordinate System” resource page

# Procedure

1 Draw a two-plane coordinate system on a sheet of graph paper. The x-axis is horizontal and placed in the paper's middle and is parallel to the long edge of the graph paper. Label this line as the x-axis. Refer to the "Understanding the Cartesian Coordinate System" resource page for help.

2 The y-axis is placed in the paper's middle and is parallel to the short edge of the graph paper. Label this line as the y-axis.

3 The x and y intersection point will represent the origin. Label this point on the graph paper as zero (0).

4 Position the metric ruler so the end point of the ruler is aligned with the origin. The ruler is parallel to the x-axis.

5 Measure and mark six lines that are 1.9 centimeters apart from each other. Each of these lines is drawn on the x-axis line to the right of the origin. This will represent the positive side of the x-coordinate plane.

6 The first coordinate point to the right of the origin along the positive x-coordinate plane is labeled with the number 1. Label the remaining five coordinate points as follows: 2, 3, 4, 5, and 6.

7 Measure and mark six lines that are 1.9 centimeters apart from each other and are drawn on the x-axis line to the left of the origin. This will represent the negative side of the x-coordinate plane.

8 The first coordinate point to the left of the origin along the negative x-coordinate plane is labeled with the number -1. Label the remaining five coordinate points as follows: -2, -3, -4, -5, and -6.

9 Measure and mark six lines that are 1.9 centimeters apart from each other. Each of these lines is drawn on the y-axis line above the origin. This will represent the positive side of the y-coordinate plane.

10 The first coordinate point above the origin along the positive y-coordinate plane is labeled with the number 1. Label the remaining five coordinate points as follows: 2, 3, 4, 5, and 6.

11 Measure and mark six lines that are 1.9 centimeters apart from each other and are drawn on the y-axis line below the origin. This will represent the negative side of the y-coordinate plane.

12 The first coordinate point below the origin along the negative y-coordinate plane is labeled with the number -1. Label the remaining five coordinate points as follows: -2, -3, -4, -5, and -6.

13 Label the positive x and positive y quadrant as Quadrant 1.

14 Label the negative x and positive y quadrant as Quadrant 2.

15 Label the negative x and negative y quadrant as Quadrant 3.

16 Label the positive x and negative y quadrant as Quadrant 4.

17 Secure the T-Bot II to the work surface.

18 Position the T-Bot II in the Home position. The Home position is the initial starting point of the T-Bot II and is identified by having all controller syringe plungers fully depressed.

19 Locate the graph paper in front of the T-Bot II. Secure the graph paper to the work surface with the use of tape.

20 Place the small foam block onto the origin of the coordinate plane.

21 You will roll the pair of dice to determine where the foam block is to be placed. The first die rolled will represent a coordinate point on the x-axis, and the second die rolled will represent a coordinate point on the y-axis. The first roll of both dice (rolled one at a time) will represent coordinate points in Quadrant 1. The second roll of both dice (rolled one at a time) will be Quadrant 2 and so forth.

22 Roll the dice to determine the Quadrant 1 coordinates. Record these coordinates in the corresponding field of the “Coordinates” worksheet.

23 Manipulate the T-Bot II to pick up the foam block and move it to the Quadrant 1 coordinates. Keep track of how many moves are required to place the foam block. Record the number of moves in the corresponding field of the “Coordinates” worksheet. Any movement of a controller syringe counts as a single move.

**24** Record the results of the T-Bot II operation in the Comments column in the table on the "Coordinates" worksheet.

**25** Repeat these steps to complete a T-Bot II operation for each of the Quadrants listed on the "Coordinates" worksheet.

A. Start the T-Bot II in the Home position.

B. Place the foam block onto the origin.

C. Roll the dice to determine the coordinates for the specified quadrant.

D. Manipulate the T-Bot II to move the foam block to the determined coordinates.

E. Complete the "Coordinates" worksheet as you finish the T-Bot II operation.

**26** Answer the questions located on the "Coordinates" worksheet.

# Coordinates

| Quadrant | x-y Coordinates | No. of Moves | Comments |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

Explain the success or failure of the T-Bot II operations for each quadrant.

Evaluate the data table to determine the number of moves for each operation. Compare and contrast these values as they relate to efficiency.

Explain how the Cartesian coordinate system might be used in programming a computer-controlled robot.

# QuickView

Students brainstorm, design, and record the steps involved in a T-Bot II program instruction set.

# Standards Addressed

NSTA 5-8
Students develop abilities necessary to do scientific inquiry.

- Students identify questions that can be answered through scientific investigations.
- Students use appropriate tools and techniques to gather, analyze, and interpret data.
- Students think critically and logically to make the relationships between evidence and explanations.
- Students communicate scientific procedures and explanations.

Students develop abilities for technological design.

- Students communicate the process of technological design.

NCTM 6-8
Students apply appropriate techniques, tools, and formulas to determine measurements.

- Students select and apply techniques and tools to accurately find length, area, volume, and angle measures to appropriate levels or precision.

Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students understand, select, and use units of appropriate size and type to measure angles, perimeter, area, surface area, and volume.

ITEEA 6-8
Students develop an understanding of the influence of technology on history.

- Students learn that the design and construction of structures for service or convenience have evolved from the development techniques for measurement, controlling systems, and the understanding of spatial relationship.

Students develop an understanding of the attributes of design.

- Students learn that design is a creative planning process that leads to useful products and systems.
- Students learn that there is no perfect design.

Students develop an understanding of engineering design.

- Students learn that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

# Time Required

45-60 minutes (will vary with class size)

# Content Areas

Primary: Technology
Secondary: Science, math

# Vocabulary

- brainstorm
- program
- protractor
- robot

# Materials

- Completed Pitsco T-Bot II
- Small foam block
- Metric ruler
- Protractor
- Paper
- Pencil

# Procedure

1 Robots are programmed to perform each movement, which results in some type of work. A programmer or engineer who works closely with the performance of a robot writes a set of program instructions. These instructions tell the robot what to do and when to do that specific movement.

2 Brainstorm ideas for a program that the T-Bot II might perform using the small foam block. The program must have a minimum of 20 steps.

*A program example might consist of the steps involved to move the foam block from Point A to Point B. Remind students to follow the general guidelines of brainstorming.*

**Brainstorming Guidelines**

- The goal of brainstorming is to develop as many solutions to the problem as possible.
- Brainstorming works best when several people are involved.
- Everyone involved should feel free to openly communicate his or her ideas.
- There are no bad ideas when brainstorming.
- Think BIG by not limiting the ideas with "It can't be done."
- Record all ideas.

3 Record a list of the program ideas on a piece of paper.

4 Select what you believe is the best idea from the brainstorm list.

5 Position the T-Bot II in the Home position. The Home position is the initial starting point of the T-Bot II and is identified by having all controller syringe plungers fully depressed.

6 Record the first program step on the paper as "Set the T-Bot II to the Home position." You should number each step as you write the program.

7 An instruction step that correctly moves the T-Bot II to complete the program must be recorded on your paper. Each program step should include which T-Bot II axis to move, the distance it moved, and possibly the angle of movement (use the protractor to determine the angle).

*Inform the students if they make an incorrect movement that they should not record that as a step. They will need to correct the error and continue from that point forward.*

8 An example program step might be: "Rotate the swivel base 15°."

9 Continue operating the T-Bot II to complete the program you have brainstormed. Make certain you record each step.

10 After the program is complete, the final step should read, “Set the T-Bot II to the Home position.” Generally speaking, a robot program instruction set begins and ends at the Home position.

11 A good method of evaluating your program instruction set is to challenge your teacher or another student to perform the instruction set using the T-Bot II. The feedback they provide will let you know if you need to correct or modify any part of the instruction set.

# QuickView

Brainstorm, design, and record the steps involved in a T-Bot II program instruction set.

# Materials

- Completed Pitsco T-Bot II
- Small foam block
- Metric ruler
- Protractor
- Paper
- Pencil

# Procedure

1 Robots are programmed to perform each movement, which results in some type of work. A programmer or engineer who works closely with the performance of a robot writes a set of program instructions. These instructions tell the robot what to do and when to do that specific movement.

2 Brainstorm ideas for a program that the T-Bot II might perform using the foam block. The program must have a minimum of 20 steps.

**Brainstorming Guidelines**

- The goal of brainstorming is to develop as many solutions to the problem as possible.
- Brainstorming works best when several people are involved.
- Everyone involved should feel free to openly communicate his or her ideas.
- There are no bad ideas when brainstorming.
- Think BIG by not limiting the ideas with “It can’t be done.”
- Record all ideas.

3 Record a list of the program ideas on a piece of paper.

4 Select what you believe is the best idea from the brainstorm list.

5 Position the T-Bot II in the Home position. The Home position is the initial starting point of the T-Bot II and is identified by having all controller syringe plungers fully depressed.

6 Record the first program step on the paper as “Set the T-Bot II to the Home position.” You should number each step as you write the program.

7 An instruction step that correctly moves the T-Bot II to complete the program must be recorded on your paper. Each program step should include which T-Bot II axis to move, the distance it moved, and possibly the angle of movement (use the protractor to determine the angle).

8 An example program step might be: “Rotate the swivel base 15°.”

9 Continue operating the T-Bot II to complete the program you have brainstormed. Make certain you record each step.

10 After the program is complete, the final step should read, “Set the T-Bot II to the Home position.” Generally speaking, a robot program instruction set begins and ends at the Home position.

11 A good method of evaluating your program instruction set is to challenge your teacher or another student to perform the instruction set using the T-Bot II. The feedback they provide will let you know if you need to correct or modify any part of the instruction set.

# QuickView

Students locate, classify, and describe the types of simple machines comprised on the T-Bot II.

# Standards Addressed

NSTA 5-8
Students develop abilities necessary to do scientific inquiry.

- Students identify questions that can be answered through scientific investigations.
- Students use appropriate tools and techniques to gather, analyze, and interpret data.
- Students think critically and logically to make the relationships between evidence and explanations.
- Students recognize and analyze alternative explanations and predictions.
- Students communicate scientific procedures and explanations.
- Students use mathematics in all aspects of scientific inquiry.

Students develop understandings about scientific inquiry.

- Students understand different kinds of questions suggest different kinds of scientific investigations and some investigations involve observing and describing objects, organisms, or events, some involve collecting specimens, some involve experiments, some involve seeking more information, some involve discovery of new objects and phenomena, and some involve making models.

ITEEA 6-9
Students develop an understanding of the influence of technology on history.

- Students learn that the design and construction of structures for service or convenience have evolved from the development techniques for measurement, controlling systems, and the understanding of spatial relationship.

Students develop an understanding of the attributes of design.

- Students learn that design is a creative planning process that leads to useful products and systems.
- Students learn that there is no perfect design.

Students develop an understanding of engineering design.

- Students learn that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

NCTM 6-8
Students recognize and apply mathematics in contexts outside of mathematics.

# Time Required

90-180 minutes (will vary with class size)

# Content Areas

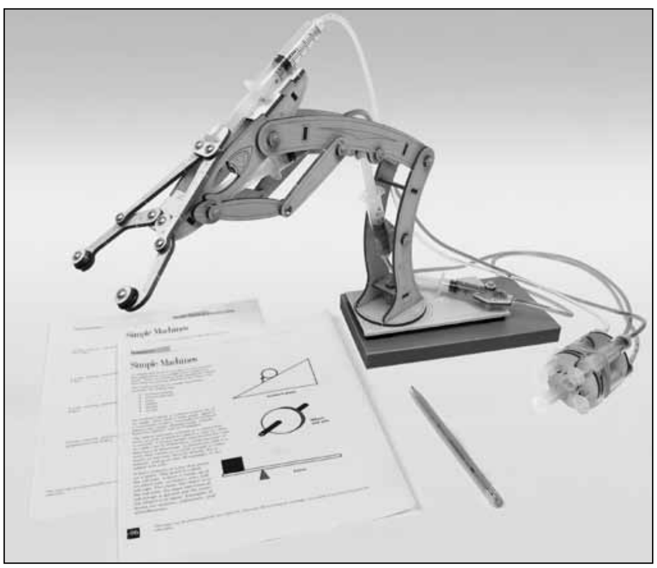
Primary: Science
Secondary: Math, technology, language arts

# Vocabulary

- end effector
- inclined plane
- lever
- pulley
- screw
- wedge
- wheel and axle

# Materials

- Completed Pitsco T-Bot II
- Pencil
- "Simple Machines" worksheet
- "Simple Machines" resource page



# Procedure

1 Locate the Pitsco T-Bot II.

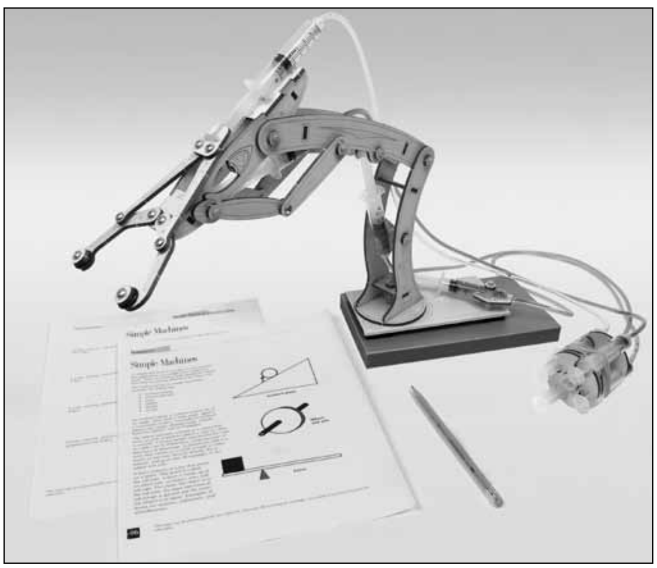
2 The T-Bot II is comprised of several different simple machines. Use the "Simple Machines" resource page to help you complete the "Simple Machines" worksheet.

# QuickView

Locate, classify, and describe the types of simple machines comprised on the T-Bot II.

# Materials

- Completed Pitsco T-Bot II
- Pencil
- "Simple Machines" worksheet
- "Simple Machines" resource page



# Procedure

1 Locate the Pitsco T-Bot II.

2 The T-Bot II is comprised of several different simple machines. Use the "Simple Machines" resource page to help you complete the "Simple Machines" worksheet.

# Simple Machines

Locate, classify, and write a brief description of each simple machine within the swivel base of the T-Bot II.

Locate, classify, and write a brief description of each simple machine within the mid-arm of the T-Bot II.

Locate, classify, and write a brief description of each simple machine within the forearm of the T-Bot II.

Locate, classify, and write a brief description of each simple machine within the end effector (grippers) of the T-Bot II.

# Quick View

Students use the T-Bot II to stack six foam blocks in the least amount of time.

# Standards Addressed

NSTA 5-8
Students develop abilities necessary to do scientific inquiry.

- Students identify questions that can be answered through scientific investigations.
- Students use appropriate tools and techniques to gather, analyze, and interpret data.
- Students think critically and logically to make the relationships between evidence and explanations.
- Students recognize and analyze alternative explanations and predictions.
- Students communicate scientific procedures and explanations.
- Students use mathematics in all aspects of scientific inquiry.

Students develop understandings about scientific inquiry.

- Students understand different kinds of questions suggest different kinds of scientific investigations and some investigations involve observing and describing objects, organisms, or events, some involve collecting specimens, some involve experiments, some involve seeking more information, some involve discovery of new objects and phenomena, and some involve making models.

Students develop abilities for technological design.

- Students evaluate completed technological designs or products.

NCTM 6-8
Students recognize and apply mathematics in contexts outside of mathematics.

ITEEA 6-8
Students develop an understanding of engineering design.

- Students learn that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

Students develop the abilities to apply the design process.

- Students learn to apply a design process to solve problems in and beyond the laboratory-classroom.
- Students learn to make a product or system and document the solution.

Students develop the abilities to assess the impact of products and systems.

- Students learn to design and use instruments to gather data.

NCTE K-12
Students adjust their use of spoken, written and visual language to communicate effectively with a variety of audiences and for different purposes.

# Time Required

180-260 minutes (will vary with class size)

# Content Areas

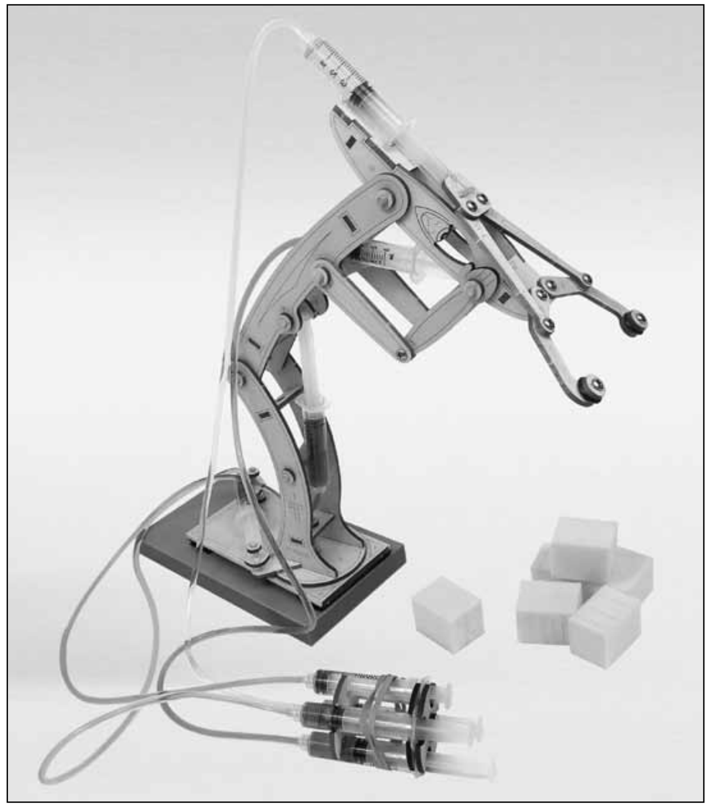
Primary: Technology
Secondary: Math, science, language arts

# Vocabulary

- brainstorm
- radius
- range of motion

# Materials

- Completed Pitsco T-Bot II
- Six small foam blocks
- Notebook/design logbook (not shown)



# Procedure

*At this point students should have completed activities in which they have performed an activity with the Cartesian coordinate system, written a set of program instructions, and identified simple machines.*

1 Brainstorm possible solutions to the problem of stacking six foam blocks in the shape of a pyramid. The shape consists of three bottom foam blocks, two middle blocks, and one top block. Your solution should be based on efficiency that will produce the fastest time. Record a description of your design solution in a notebook or design logbook.

*Depending on the level of the students, you may need to demonstrate some possibilities for keeping a log of designs and design modifications. One method would be to keep a notebook with sketches, data, materials, and explanations of changes with dates and times for each entry. You may create a structured format for students to do this, or you may choose to give them an example and allow them to approach the record keeping in a more free-form style.*

2 Evaluate the strengths and weaknesses of your design solution. Brainstorm ideas as to what changes could be made to the program instruction set that would make it more efficient. Use sketches and/or written paragraphs. Include a date and time with each entry.

3 Test the program instruction set that results in stacking the foam blocks. Record the performance time in your notebook.

4 Modify the program instruction set, making any design changes you feel necessary.

5 Test the program instruction set once again. Compare the two tests and evaluate the results.

6 Write a report summarizing the design and testing process you completed. Include which design was most successful. Give reasons why you think that design was successful. Include any factors you believe may have contributed to the success or failure of the designs.

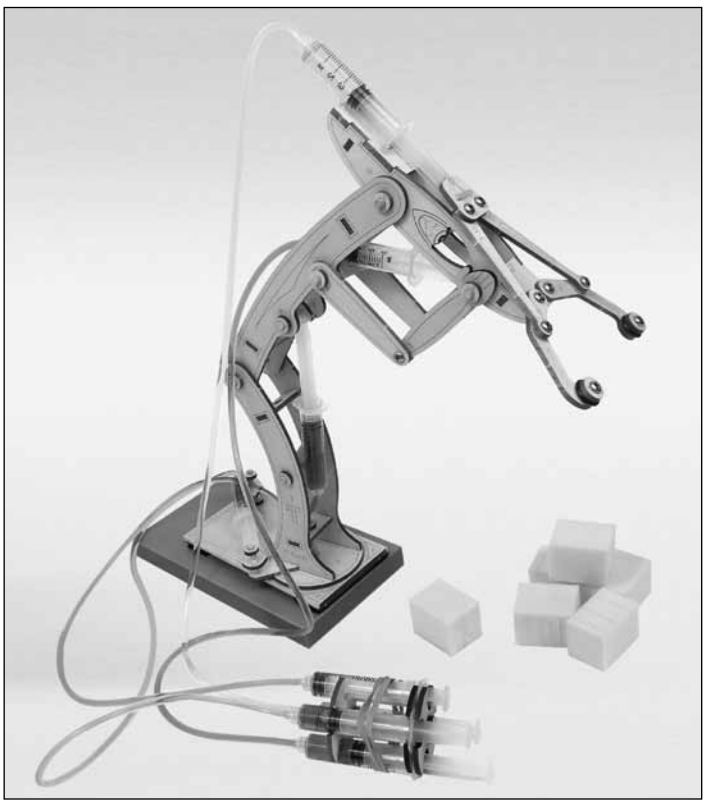
*You may give students a structured format to use for the report. They should identify the design problem, proposed solution, steps used to test the proposed solution, design modifications, retesting procedures, testing results, and evaluation of the design solution.*

# QuickView

Use the T-Bot II to stack six foam blocks in the least amount of time.

# Materials

- Completed Pitsco T-Bot II
- Six small foam blocks
- Notebook/design logbook (not shown)



# Procedure

1 Brainstorm possible solutions to the problem of stacking six foam blocks in the shape of a pyramid. The shape consists of three bottom foam blocks, two middle blocks, and one top block. Your solution should be based on efficiency that will produce the fastest time. Record a description of your design solution in a notebook or design logbook.

2 Evaluate the strengths and weaknesses of your design solution. Brainstorm ideas as to what changes could be made to the program instruction set that would make it more efficient. Use sketches and/or written paragraphs. Include a date and time with each entry.

3 Test the program instruction set that results in stacking the foam blocks. Record the performance time in your notebook.

4 Modify the program instruction set, making any design changes you feel necessary.

5 Test the program instruction set once again. Compare the two tests and evaluate the results.

6 Write a report summarizing the design and testing process you completed. Include which design was most successful. Give reasons why you think that design was successful. Include any factors you believe may have contributed to the success or failure of the designs.

# QuickView

Students determine the range of motion for each axis of the T-Bot II.

# Standards Addressed

NSTA 9-12
Students develop the abilities to do scientific inquiry.
- Students identify questions and concepts that guide scientific investigations.
- Students design and conduct scientific investigations.
- Students use technology and mathematics to improve investigations and communications.
- Students formulate and revise scientific explanations and models using logic and evidence.
- Students communicate and defend a scientific argument.

NCTM 9-12
Students compute fluently and make reasonable estimates.
- Students judge the reasonableness of numerical computations and their results.

Students use mathematical models to represent and understand quantitative relationships.
- Students draw reasonable conclusions about a situation being modeled.

Students understand measurement attributes of objects and the units, systems, and processes of measurement.
- Students make decisions about units and scales that are appropriate for problem situations involving measurement.

Students recognize and use connections among mathematical ideas.
- Students recognize and apply mathematics in contexts outside of mathematics.

Students understand meanings of operations and how they relate to one another.
- Students judge the effects of such operations as multiplication, division, and computing powers and roots on the magnitudes on quantities.

Students understand patterns, relations, and functions.
- Students interpret representations of functions of two variables.

Students represent and analyze mathematical situations and structures using algebraic symbols.
- Students understand the meaning of equivalent forms of expressions, equations, inequalities, and relations.
- Students use symbolic algebra to represent and explain mathematical relationships.

Students analyze characteristics and properties of two- and three-dimensional shapes and develop mathematical arguments about geometric relationships.
- Students use trigonometric relationships to determine lengths and angle measures.

Students understand measurable attributes of objects and the units, systems, and processes of measurement.
- Students make decisions about units and scales that are appropriate for problem situations involving measurement.

Students apply appropriate techniques, tools, and formulas to determine measurements.
- Students use unit analysis to check measurement computations.

Students build new mathematical knowledge through problem solving.
- Students solve problems that arise in mathematics and in other contexts.
- Students apply and adapt a variety of appropriate strategies to solve problems.
- Students monitor and reflect on the process of mathematical problem solving.

Students organize and consolidate their mathematical thinking through communication.
- Students communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
- Students use the language of mathematics to express mathematical ideas precisely.

Students recognize and use connections among mathematical ideas.
- Students recognize and apply mathematics in contexts outside of mathematics.

Students create and use representations to organize, record, and communicate mathematical ideas.
- Students select, apply, and translate among mathematical representations to solve problems.

ITEEA 9-12
Students develop an understanding of the attributes of design.
- Students learn design problems are rarely presented in a clearly defined form.
- Students learn that design needs to be continually checked and critiqued and the ideas of the design must be redefined and improved.

# Time Required

45-90 minutes (will vary with class size)

# Content Areas

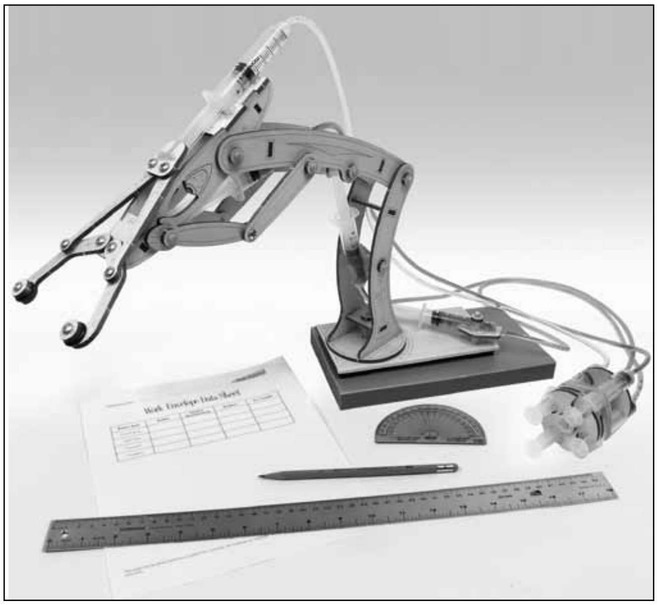
Primary: Math
Secondary: Technology, science, language arts

# Vocabulary

- arc length
- axis
- radius
- range of motion

# Materials

- Completed Pitsco T-Bot II
- Pencil
- Metric ruler
- "Work Envelope Data Sheet"
- Protractor



# Procedure

1 The area in which a robot can perform work is called the work envelope. The T-Bot II has a work envelope that is shaped similar to one quarter of a globe.

2 Locate the Pitsco T-Bot II.

3 Locate the T-Bot II's four different axes of motion. An axis is the point at which a body or a part rotates. The T-Bot II moves in four axes of motion: Axis 1 – where the swivel base connects to the platform; Axis 2 – where the mid-arm connects to the swivel base; Axis 3 – where the mid-arm connects to the forearm; and Axis 4 – where the end effector (grippers) connects to the forearm.

4 Determine the range of motion of the swivel base. The formula for figuring arc length is: Arc Length = Radius x Radians. Radians = Degree Measurement x (π/180)

*Students will need to use a protractor and ruler to obtain the measurements.*

5 Record these measurements on the "Work Envelope Data Sheet."

6 Repeat these steps for the mid-arm, the forearm, and the grippers.

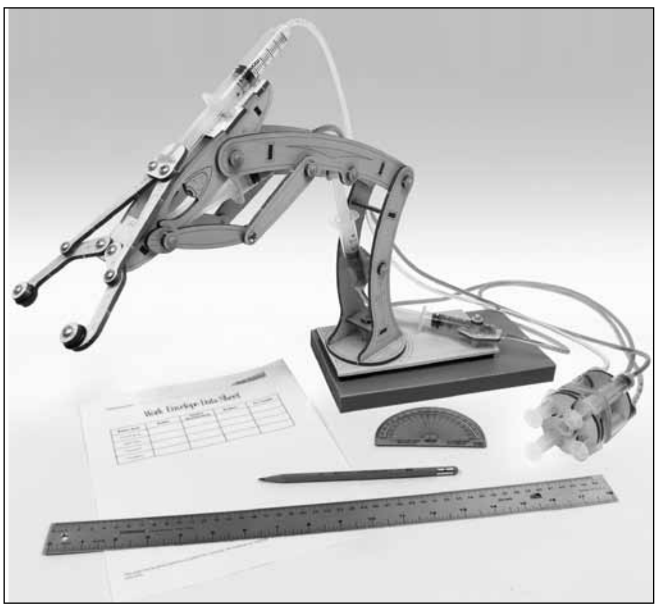
7 Using the measurements obtained, complete the "Work Envelope Data Sheet."

# QuickView

Determine the range of motion for each axis of the T-Bot II.

# Materials

- Completed Pitsco T-Bot II
- Pencil
- Metric ruler
- "Work Envelope Data Sheet"
- Protractor



# Procedure

1 The area in which a robot can perform work is called the work envelope. The T-Bot II has a work envelope that is shaped similar to one quarter of a globe.

2 Locate the Pitsco T-Bot II.

3 Locate the T-Bot II's four different axes of motion. An axis is the point at which a body or a part rotates. The T-Bot II moves in four axes of motion: Axis 1 – where the swivel base connects to the platform; Axis 2 – where the mid-arm connects to the swivel base; Axis 3 – where the mid-arm connects to the forearm; and Axis 4 – where the end effector (grippers) connects to the forearm.

4 Determine the range of motion of the swivel base. The formula for figuring arc length is: Arc Length = Radius x Radians. Radians = Degree Measurement x ($\pi$/180)

5 Record these measurements on the "Work Envelope Data Sheet."

6 Repeat these steps for the mid-arm, the forearm, and the grippers.

7 Using the measurements obtained, complete the "Work Envelope Data Sheet."

# Work Envelope Data Sheet

| Robot Axes | Radius | Degree Measurement | Radians | Arc Length |
|---|---|---|---|---|
| Swivel base | | | | |
| Mid-arm | | | | |
| Forearm | | | | |
| Grippers | | | | |

# QuickView

Students determine the mechanical advantage of one of the arms (levers) of the T-Bot II.

# Standards Addressed

NSTA 9-12
Students develop the abilities to do scientific inquiry.

- Students identify questions and concepts that guide scientific investigations.
- Students design and conduct scientific investigations.
- Students use technology and mathematics to improve investigations and communications.
- Students formulate and revise scientific explanations and models using logic and evidence.
- Students communicate and defend a scientific argument.

Students develop understandings about scientific inquiry.

- Students understand mathematics is essential in scientific inquiry and understand mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations, and communicating results.

Students understand motions and forces.

- Students understand objects change their motion only when a net force is applied; understand laws of motion are used to calculate precisely the effects of forces on the motion of objects; understand the magnitude of the change in motion can be calculated using the relationship $F = ma$, which is independent of the nature of force; and understand whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

Students understand about science and technology.

- Students understand creativity, imagination, and a good knowledge base are all required in the work of science and engineering.

Students understand the nature of scientific knowledge.

- Students understand scientific explanations must meet certain criteria; understand first and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied; understand they should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public; and understand explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.

NCTM 9-12
Students compute fluently and make reasonable estimates.

- Students develop fluency in operations with real numbers, vectors, and matrices, using mental computation or paper-and-pencil calculations for simple cases and technology for more complicated cases.

Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students make decisions about units and scales that are appropriate for problem situations involving measurement.

ITEEA 9-12
Students develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

- Students learn technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.
- Students learn technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.
- Students learn technological progress promotes the advancement of science and mathematics.

Students develop an understanding of engineering design.

- Students learn established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

# Time Required

90-135 minutes (will vary with class size)

# Content Areas

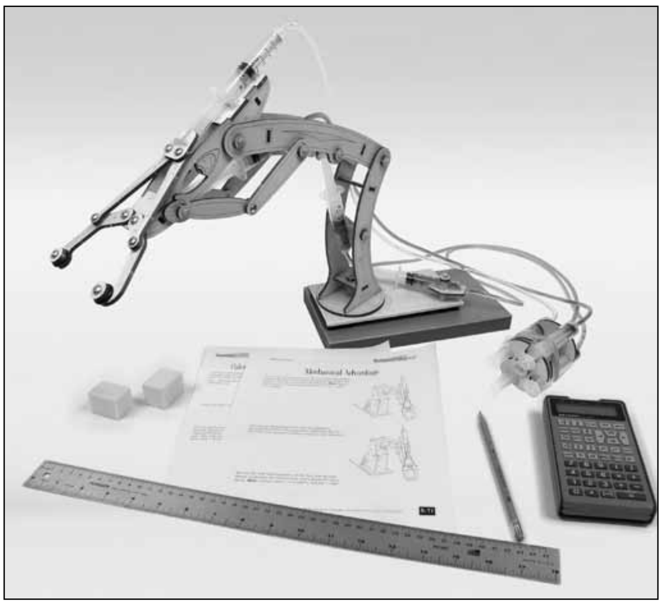
Primary: Science
Secondary: Math, technology, language arts

# Vocabulary

- axes
- effort arm
- fulcrum
- resistance arm

# Materials

- Completed Pitsco T-Bot II
- Pencil
- "Calculating Mechanical Advantage" resource page
- "Mechanical Advantage" worksheet
- Metric ruler
- Two small foam blocks (varying in size)
- Calculator



# Procedure

1 Read the "Calculating Mechanical Advantage" resource page.

*Make sure the students read the resource page on mechanical advantage before starting this activity.*

2 Locate the Pitsco T-Bot II.

3 Using the T-Bot II, pick up the first foam block and extend the axes of the T-Bot II completely.

4 Record the measurements of the distance from the fulcrum to the effort arm and the distance from the fulcrum to the resistance arm on the "Mechanical Advantage" worksheet.

*All measurements should be taken in centimeters.*

5 Using the T-Bot II, pick up the second block and extend the axes of the T-Bot II completely.

6 Record the measurements of the distance from the fulcrum to the effort arm and the distance from the fulcrum to the resistance arm on the "Mechanical Advantage" worksheet.

*All measurements should be taken in centimeters.*

7 Complete the "Mechanical Advantage" worksheet.

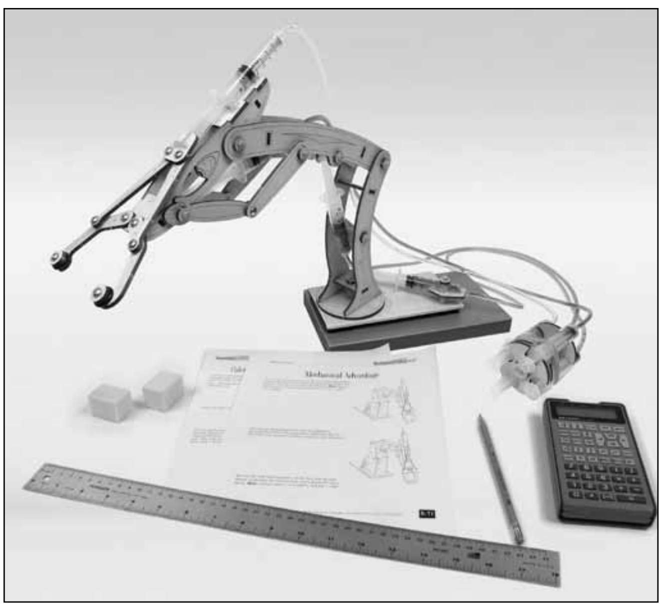
*Students may need a calculator for the remainder of the worksheet.*

# QuickView

Determine the mechanical advantage of one of the arms (levers) of the T-Bot II.

# Materials

- Completed Pitsco T-Bot II
- Pencil
- "Calculating Mechanical Advantage" resource page
- "Mechanical Advantage" worksheet
- Metric ruler
- Two small foam blocks (varying in size)
- Calculator



# Procedure

1 Read the "Calculating Mechanical Advantage" resource page.

2 Locate the Pitsco T-Bot II.

3 Using the T-Bot II, pick up the first foam block and extend the axes of the T-Bot II completely.

4 Record the measurements of the distance from the fulcrum to the effort arm and the distance from the fulcrum to the resistance arm on the "Mechanical Advantage" worksheet.

5 Using the T-Bot II, pick up the second block and extend the axes of the T-Bot II completely.

6 Record the measurements of the distance from the fulcrum to the effort arm and the distance from the fulcrum to the resistance arm on the "Mechanical Advantage" worksheet.

7 Complete the "Mechanical Advantage" worksheet.

# Mechanical Advantage

Record the measurements for the first foam block movements of the T-Bot II axes here. Label the data for the effort arm distance and the resistance arm distance. **Hint:** Figure the distances of the mid-arm and the forearm. Label your results.

Record the measurements for the second foam block movements of the T-Bot II axes here. Label the data for the effort arm distance and the resistance arm distance.

Record the side measurements of the first and second foam blocks. Calculate the surface area and volume for each block.
**Hint:** Surface Area = 6 x (side$^2$); Volume = side$^3$

## Mechanical Advantage continued

What is the formula for solving the mechanical advantage of a lever?

Calculate the mechanical advantage of the levers of each block and record those results here.

Draw conclusions about how the size and mass of objects affect the mechanical advantage of a machine.

# QuickView

Students design and construct an electromagnetic end effector to modify the grippers.

# Standards Addressed

NSTA 9-12
Students develop the abilities to do scientific inquiry.

- Students identify questions and concepts that guide scientific investigations.
- Students design and conduct scientific investigations.
- Students use technology and mathematics to improve investigations and communications.
- Students formulate and revise scientific explanations and models using logic and evidence.
- Students communicate and defend a scientific argument.

NCTM 9-12
Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students make decisions about units and scales that are appropriate for problem situations involving measurement.

Students recognize and use connections among mathematical ideas.

- Students recognize and apply mathematics in contexts outside of mathematics.

ITEEA 9-12
Students develop an understanding of the attributes of design.

- Students learn design problems are rarely presented in a clearly defined form.
- Students learn that design needs to be continually checked and critiqued and the ideas of the design must be redefined and improved.

Students develop abilities to apply the design process.

- Students learn to develop and produce a product or system using a design process.
- Students learn to evaluate final solutions and communicate observations, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

NCTE K-12
Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes.

# Time Required

90-180 minutes (will vary with class size)

# Content Areas

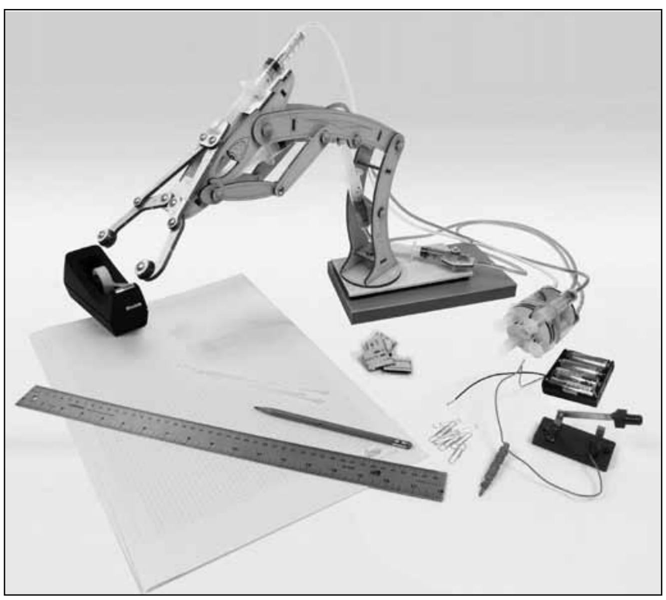
Primary: Technology
Secondary: Math, science, language arts

# Vocabulary

- electromagnet
- end effector

# Materials

- Completed Pitsco T-Bot II
- Battery-powered electromagnet with a switch (see "Electromagnet" resource page)
- Graph paper
- Pencil
- Zip ties
- Tape
- Hook-and-loop fasteners
- Metric ruler
- Paper clips



# Procedure

1 Brainstorm ideas to create a T-Bot II with an electromagnetic end effector. Record these ideas in a list. Included in the list should be how to attach the electromagnet, where to place the battery, and where the switch should be located.

2 Using graph paper, design a modified T-Bot II with an electromagnetic end effector. Draw the model to scale.

*Have the students create a key to label what scale they used. The designs will need your approval before they begin the modifications.*

3 Add the electromagnet to the end effector as your design indicates.
**Note:** Your teacher may require you to build the electromagnet following instructions on the “Electromagnet” resource page.

*Students may use zip ties, tape, hook-and-loop fasteners, or other items to attach the electromagnet to the grippers.*

4 Turn on your electromagnet. Use the T-Bot II to pick up multiple paper clips with the newly modified end effector.

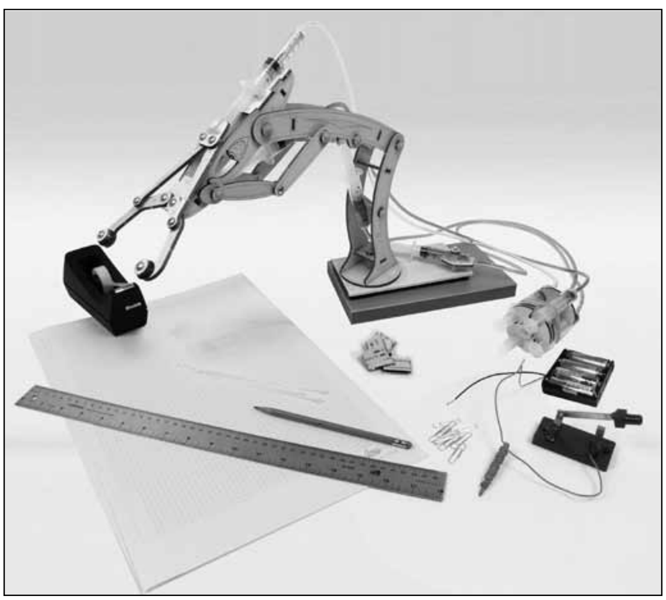
*Paper clips work well for this test. A class competition could be used here, awarding a prize to the team who can pick up the most paper clips.*

# QuickView

Design and construct an electromagnetic end effector to modify the grippers.

# Materials

- Completed Pitsco T-Bot II
- Battery-powered electromagnet with a switch (see "Electromagnet" resource page)
- Graph paper
- Pencil
- Zip ties
- Tape
- Hook-and-loop fasteners
- Metric ruler
- Paper clips



# Procedure

1 Brainstorm ideas to create a T-Bot II with an electromagnetic end effector. Record these ideas in a list. Included in the list should be how to attach the electromagnet, where to place the battery, and where the switch should be located.

2 Using graph paper, design a modified T-Bot II with an electromagnetic end effector. Draw the model to scale.

3 Add the electromagnet to the end effector as your design indicates.
**Note:** Your teacher may require you to build the electromagnet following instructions on the “Electromagnet” resource page.

4 Turn on your electromagnet. Use the T-Bot II to pick up multiple paper clips with the newly modified end effector.

# QuickView

Students design a T-Bot II production line to move “products” (foam blocks) from one end of a “warehouse” (classroom work surface) to the other.

# Standards Addressed

NSTA 9-12
Students develop the abilities to do scientific inquiry.

- Students identify questions and concepts that guide scientific investigations.
- Students design and conduct scientific investigations.
- Students use technology and mathematics to improve investigations and communications.
- Students formulate and revise scientific explanations and models using logic and evidence.
- Students communicate and defend a scientific argument.

NCTM 9-12
Students compute fluently and make reasonable estimates.

- Students judge the reasonableness of numerical computations and their results.

Students understand measurable attributes of objects and the units, systems, and processes of measurement.

- Students make decisions about units and scales that are appropriate for problem situations involving measurement.

Students recognize and use connections among mathematical ideas.

- Students recognize and apply mathematics in contexts outside of mathematics.

ITEEA 9-12
Students develop an understanding of the attributes of design.

- Students learn design problems are rarely presented in a clearly defined form.
- Students learn that design needs to be continually checked and critiqued and the ideas of the design must be redefined and improved.

Students develop abilities to apply the design process.

- Students learn to identify the design problem to solve and decide whether or not to address it.
- Students learn to evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.
- Students learn to develop and produce a product or system using a design process.
- Students learn to evaluate final solutions and communicate observations, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

Students develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

- Students learn technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.

NCTE K-12
Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes.

# Time Required

225-550 minutes (will vary with class size)

# Content Areas

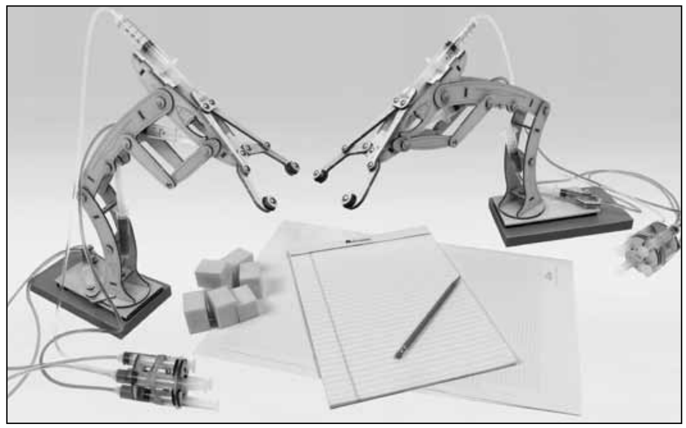
Primary: Technology
Secondary: Math, science, language arts

# Vocabulary

- brainstorm
- program
- range of motion

# Materials

- Pencil
- Paper
- Graph paper
- Multiple Pitsco T-Bot IIs
- Small foam blocks
- Designated work area



# Procedure

*Students could work in teams of three or four. They could draw up their designs and present them to the whole class. This would take several days for designing and then one class period for each team to explain and set up their lines with the class. This could be a class competition.*

1 Brainstorm ideas for a production line that utilizes multiple T-Bot IIs.

*Remind students to follow the general guidelines of brainstorming.*

**Brainstorming Guidelines**

- The goal of brainstorming is to develop as many solutions to the problem as possible.
- Brainstorming works best when several people are involved.
- Everyone involved should feel free to openly communicate his or her ideas.
- There are no bad ideas when brainstorming.
- Think BIG by not limiting the ideas with “It can’t be done.”
- Record all ideas.

2 Record a list of these ideas on paper.

3 Select what you believe is the best idea from the brainstorm list.

4 Use the graph paper to design the production line your team has selected. Make sure to use detail when designing your production line.

*A competition could be made out of this activity, judging on time taken to move the items or the lowest number of T-Bot IIs used or complexity of the production line. Students could also have to assemble a product while moving the blocks from the starting point to the ending point. An example of a production line could be moving a foam block through the line while adding small items to the block at the various T-Bot II stations.*

5 Select a group leader to present your production line idea to the entire class.

*Students should be well prepared for their presentation.*

6 After your presentation is completed, assemble your production line and move the foam blocks from the designated starting point to the designated ending point.

7 Write a report summarizing the design and testing process you completed. Give reasons why you think your design was successful or unsuccessful. Include factors that may have contributed to the success or failure of the designs.

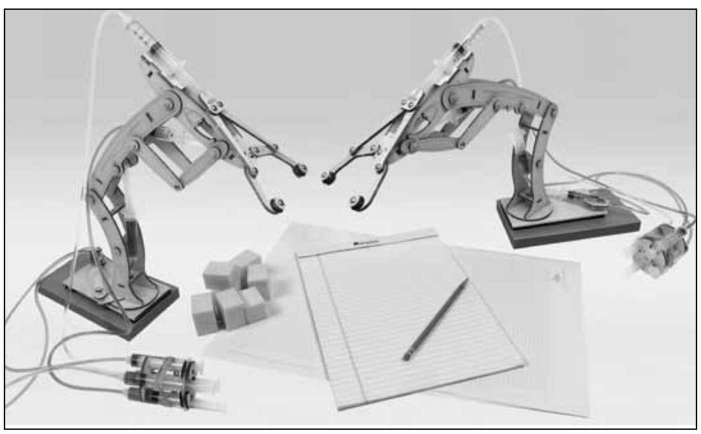
*Students should use correct punctuation, grammar, and essay form when writing their reports.*

# QuickView

Design a T-Bot II production line to move "products" (foam blocks) from one end of a "warehouse" (classroom work surface) to the other.

# Materials

- Pencil
- Paper
- Graph paper
- Multiple Pitsco T-Bot IIs
- Small foam blocks
- Designated work area



# Procedure

1 Brainstorm ideas for a production line that utilizes multiple T-Bot II.

**Brainstorming Guidelines**

- The goal of brainstorming is to develop as many solutions to the problem as possible.
- Brainstorming works best when several people are involved.
- Everyone involved should feel free to openly communicate his or her ideas.
- There are no bad ideas when brainstorming.
- Think BIG by not limiting the ideas with "It can't be done."
- Record all ideas.

2 Record a list of these ideas on paper.

3 Select what you believe is the best idea from the brainstorm list.

4 Use the graph paper to design the production line your team has selected. Make sure to use detail when designing your production line.

5 Select a group leader to present your production line idea to the entire class.

6 After your presentation is completed, assemble your production line and move the foam blocks from the designated starting point to the designated ending point.

7 Write a report summarizing the design and testing process you completed. Give reasons why you think your design was successful or unsuccessful. Include factors that may have contributed to the success or failure of the designs.

# Supplemental Lessons

- Design components of a T-Bot II.
- Design a T-Bot II for specific criteria.
- Organize a class competition.

# Vocabulary

- arc length
- axes
- brainstorm
- Cartesian coordinate system
- coordinate
- effort arm
- electromagnet
- end effector
- fulcrum
- inclined plane
- intersection
- lever
- origin
- program
- protractor
- pulley
- radius
- range of motion
- resistance arm
- robot
- screw
- wedge
- wheel and axle
- x-axis
- y-axis

# T-Bot II Word Search

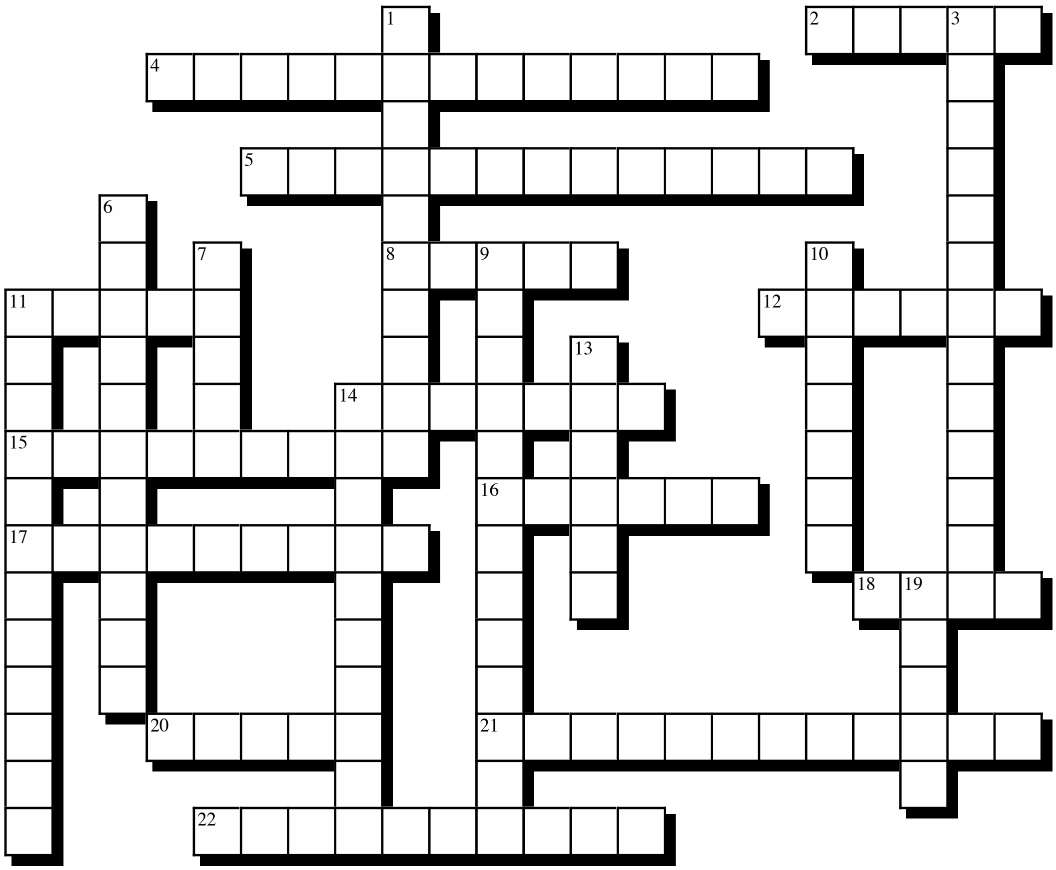
| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | O | I | T | O | M | F | O | E | G | N | A | R | M | R | S | E | T | S | E | S | E | R | E | E |
| S | E | T | T | E | O | R | E | C | I | T | R | N | O | U | U | A | I | I | A | X | E | S | N | L |
| E | L | E | R | F | N | T | I | G | E | A | X | I | N | N | R | R | E | X | N | N | M | R | A | E |
| F | X | I | D | G | I | I | I | R | R | H | G | A | T | O | W | C | C | A | T | C | E | D | L | C |
| W | A | R | N | N | W | R | F | A | A | R | A | N | N | G | I | R | L | X | A | S | O | I | A | T |
| R | D | D | T | C | O | R | Y | E | L | N | Y | N | M | E | T | T | R | U | I | E | I | G | T | R |
| S | N | F | R | R | L | M | R | A | T | R | O | F | F | E | R | S | C | S | F | E | N | T | T | O |
| C | A | R | T | E | S | I | A | N | C | O | O | R | D | I | N | A | T | E | S | Y | S | T | E | M |
| E | L | T | F | E | C | P | N | R | F | T | L | U | R | R | U | A | S | S | S | L | A | P | R | A |
| I | E | I | F | A | A | O | R | E | T | L | T | R | V | A | N | I | S | N | L | R | L | A | A | G |
| W | E | M | E | S | R | N | O | R | D | R | Y | R | N | C | D | A | M | G | E | L | E | C | A | N |
| I | H | E | R | I | C | S | F | R | O | P | E | C | E | T | P | I | S | N | V | F | L | T | R | E |
| F | W | N | M | L | E | N | T | B | D | L | L | A | Y | A | R | R | U | W | E | R | C | S | N | T |
| U | I | I | E | E | T | R | O | L | P | I | R | A | R | O | O | L | Y | S | R | C | R | M | N | I |
| E | C | E | E | C | D | T | F | R | R | M | N | C | N | F | T | N | E | E | A | R | A | N | N | T |
| B | R | A | I | N | S | T | O | R | M | R | L | A | A | E | R | E | Y | Y | R | I | D | F | E | D |
| M | Y | I | U | G | S | P | A | W | O | E | L | F | T | C | A | T | T | R | T | T | R | T | N | W |
| G | E | I | R | B | L | R | F | T | N | L | L | A | D | E | C | P | U | L | L | E | Y | Y | O | R |
| E | E | N | M | A | S | T | C | G | A | F | N | I | A | O | T | R | R | I | A | X | H | O | D | M |
| G | G | L | U | I | S | E | T | S | T | C | E | N | L | E | O | R | U | R | S | S | R | O | T | A |
| U | L | D | X | U | F | H | E | N | I | Y | D | C | E | N | R | W | R | R | A | T | R | U | F | R |
| T | U | A | E | F | A | E | M | F | H | N | M | R | D | A | O | Y | D | R | F | F | R | M | L | G |
| R | Y | C | E | W | D | O | T | F | T | R | E | D | H | Y | T | R | I | B | L | R | R | R | R | O |
| L | E | D | U | R | N | N | U | T | U | Y | N | R | R | T | R | R | E | U | N | S | P | H | T | R |
| R | N | C | N | E | G | O | S | I | T | F | I | C | E | R | U | A | E | N | E | W | L | R | T | P |
| E | T | B | A | A | A | I | S | E | A | R | S | I | D | A | R | F | R | T | A | R | T | L | U | S |

ARC LENGTH
AXES
BRAINSTORM
CARTESIAN COORDINATE SYSTEM
COORDINATE
EFFORT ARM
ELECTROMAGNET
END EFFECTOR
FULCRUM
INCLINED PLANE
INTERSECTION
LEVER
ORIGIN
PROGRAM
PROTRACTOR
PULLEY
RADIUS
RANGE OF MOTION
RESISTANCE ARM
ROBOT
SCREW
WEDGE
WHEEL AND AXLE
X-AXIS
Y-AXIS

# T-Bot II Word Search Answers

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | O | I | T | O | M | F | O | E | G | N | A | R | M | R | S | E | T | S | E | S | E | R | E | E |
| S | E | T | T | E | O | R | E | C | I | T | R | N | O | U | U | A | I | I | A | X | E | S | N | L |
| E | L | E | R | F | N | T | I | G | E | A | X | I | N | N | R | R | E | X | N | N | M | R | A | E |
| F | X | I | D | G | I | I | I | R | R | H | G | A | T | O | W | C | C | A | T | C | E | D | L | C |
| W | A | R | N | N | W | R | F | A | A | R | A | N | N | G | I | R | L | X | A | S | O | I | A | T |
| R | D | D | T | C | O | R | Y | E | L | N | Y | N | M | E | T | T | R | U | I | E | I | G | T | R |
| S | N | F | R | R | L | M | R | A | T | R | O | F | F | E | R | S | C | S | F | E | N | T | T | O |
| C | A | R | T | E | S | I | A | N | C | O | O | R | D | I | N | A | T | E | S | Y | S | T | E | M |
| E | L | T | F | E | C | P | N | R | F | T | L | U | R | R | U | A | S | S | S | L | A | P | R | A |
| I | E | I | F | A | A | O | R | E | T | L | T | R | V | A | N | I | S | N | L | R | L | A | A | G |
| W | E | M | E | S | R | N | O | R | D | R | Y | R | N | C | D | A | M | G | E | L | E | C | A | N |
| I | H | E | R | I | C | S | F | R | O | P | E | C | E | T | P | I | S | N | V | F | L | T | R | E |
| F | W | N | M | L | E | N | T | B | D | L | L | A | Y | A | R | R | U | W | E | R | C | S | N | T |
| U | I | I | E | E | T | R | O | L | P | I | R | A | R | O | O | L | Y | S | R | C | R | M | N | I |
| E | C | E | E | C | D | T | F | R | R | M | N | C | N | F | T | N | E | E | A | R | A | N | N | T |
| B | R | A | I | N | S | T | O | R | M | R | L | A | A | E | R | E | Y | Y | R | I | D | F | E | D |
| M | Y | I | U | G | S | P | A | W | O | E | L | F | T | C | A | T | T | R | T | T | R | T | N | W |
| G | E | I | R | B | L | R | F | T | N | L | L | A | D | E | C | P | U | L | L | E | Y | Y | O | R |
| E | E | N | M | A | S | T | C | G | A | F | N | I | A | O | T | R | R | I | A | X | H | O | D | M |
| G | G | L | U | I | S | E | T | S | T | C | E | N | L | E | O | R | U | R | S | S | R | O | T | A |
| U | L | D | X | U | F | H | E | N | I | Y | D | C | E | N | R | W | R | R | A | T | R | U | F | R |
| T | U | A | E | F | A | E | M | F | H | N | M | R | D | A | O | Y | D | R | F | F | R | M | L | G |
| R | Y | C | E | W | D | O | T | F | T | R | E | D | H | Y | T | R | I | B | L | R | R | R | R | O |
| L | E | D | U | R | N | N | U | T | U | Y | N | R | R | T | R | R | E | U | N | S | P | H | T | R |
| R | N | C | N | E | G | O | S | I | T | F | I | C | E | R | U | A | E | N | E | W | L | R | T | P |
| E | T | B | A | A | A | I | S | E | A | R | S | I | D | A | R | F | R | T | A | R | T | L | U | S |

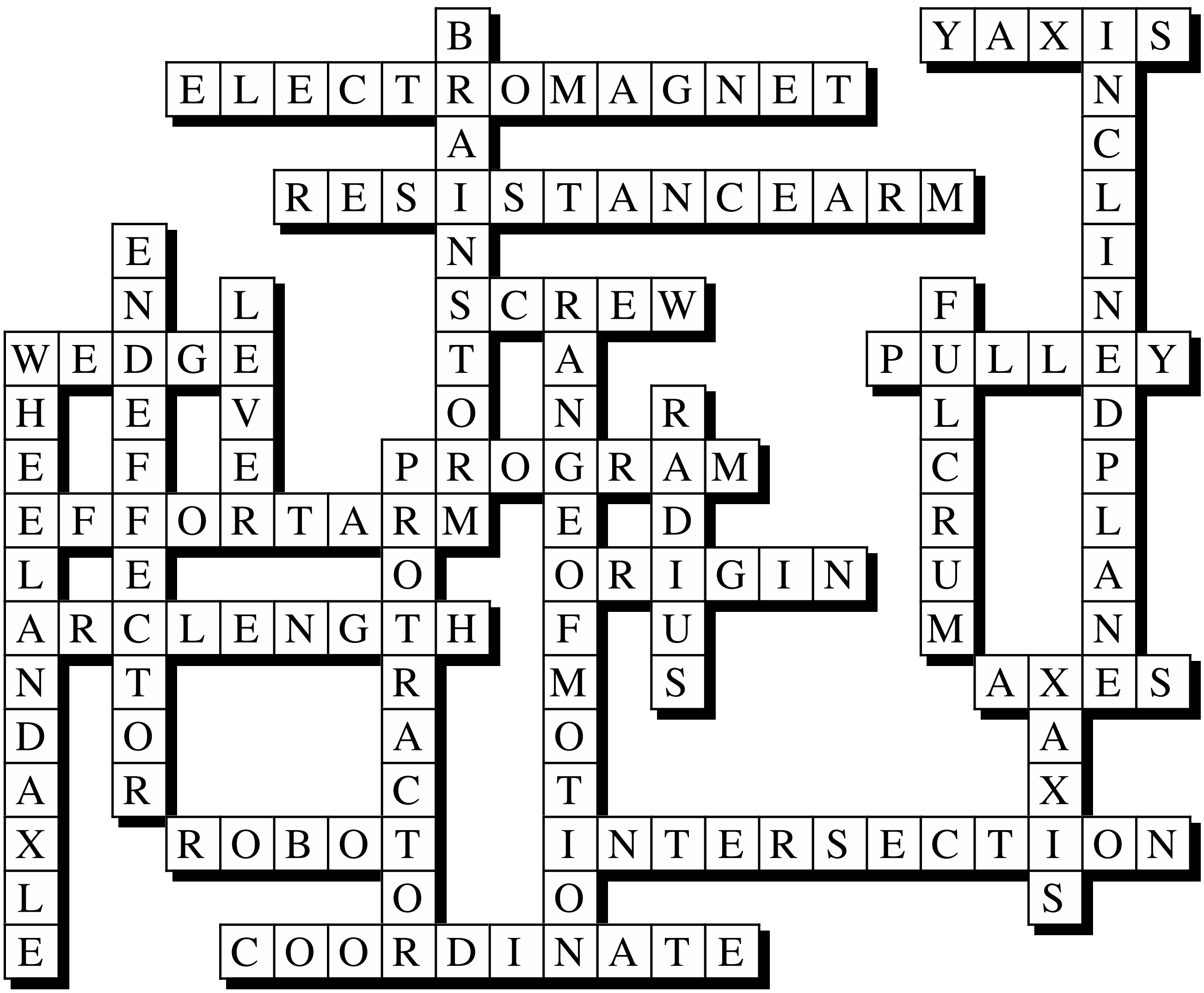
# T-Bot II Crossword Puzzle




ACROSS
2 the vertical axis in a two-dimensional coordinate system such as a graph
4 a magnet consisting of a core, often made of soft iron, that is temporarily magnetized by an electric current in a coil that surrounds it
5 the part of the lever that is in opposition to the effort, or force
8 a spiral inclined plane
11 the simple machine that consists of an inclined plane with one or two sloping sides
12 the simple machine that uses a rope that passes through a grooved wheel
14 a set of coded operating instructions that is used to run a machine automatically
15 the part of a lever on which a person or machine applies a force
16 the point of intersection of all axes in a coordinate system
17 the distance of a section of a circle or other curved figure
18 the reference lines of a coordinate system
20 any machine that can be programmed to carry out instructions and perform particular duties, especially one that can take over tasks normally done by people
21 the place or point where two things cross each other
22 the location of a point on the x-y plane

DOWN
1 to generate creative ideas spontaneously
3 the simple machine made up of a slanted, flat surface
6 a device or tool connected to the end of a robot arm
7 the simple machine consisting of a bar that pivots on a point called a fulcrum
9 the degree of movement possible from a joint
10 the point or support about which a lever turns
11 the simple machine consisting of a wheel and a rod or shaft around which the wheel turns; the rod supports the wheel's center and turns with the wheel
13 the distance from the center of a circle to its outer edge; half of the diameter
14 an instrument shaped like a semicircle marked with the degrees of a circle used to measure or mark angles
19 the horizontal axis in a two-dimensional coordinate system such as a graph

# T-Bot II Crossword Puzzle Answers



# Careers Related to Design, Mechanical Engineering, and Robotics

- Applications Engineers
- Electro-Mechanical Technicians
- Field Technicians
- Hydraulic and Pneumatic Technicians
- Mechanical Engineers
- Mechanical Drafters

Additional information about each career can be found by logging on to http://www.bls.gov/oco or online.onetcenter.org/find.

## Activity Suggestion

Have students create a robotics pamphlet detailing career information such as skills required, nature of work, and level of education. Students should include information for at least two careers.

# History of Robotics

The word *robot* was introduced by Czech writer Karel Capek in his play "Rossum's Universal Robots," which was written in 1920.

Ideas similar to today's robot can be found as long ago as 450 B.C. when the Greek mathematician Archytas of Tarentum proposed a mechanical bird he called "The Pigeon," which was propelled by steam. In the twelfth century, a Turkish inventor designed and constructed automatic machines such as water clocks and kitchen appliances powered by water.

In the late fifteenth century, Leonardo da Vinci made one of the first recorded designs of a humanoid robot. Da Vinci's notebooks showed detailed drawings of a mechanical knight able to sit up, wave its arms, and move its head and jaw. There is no record that he tried to build this robot.

Many consider the first modern robot to be a tele-operated boat that was demonstrated at an 1898 exhibition in Madison Square Garden.

Robots are machines programmed to carry out procedures in a way similar to humans. In 1962 the first industrial robot was sold in the U.S. It could pick up and reposition items. Japan used these types of robots for welding, painting, and controlling other machines.

Today, robots are popular with automobile and many other manufacturers because they do not tire and almost never make mistakes while doing their jobs. They are also used to perform tasks that are dangerous or too hard for humans to do.

Asimo, a robot built by Honda, at Autosaloon 2005 in Japan. Honda's goal was to create a humanoid robot that could assist and live with people.

*Photo courtesy of morgueFile.com.*

# Levers

A lever is a simple machine consisting of a bar that pivots on a fixed point. This fixed point is called a fulcrum. Levers reduce the amount of force needed to perform work. To move an object with a lever, force is applied to one end of the lever, and the object to be moved (load) is usually located at the other end of the lever, with the fulcrum somewhere between the two.

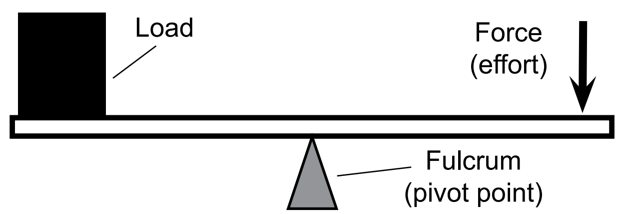
Work is defined as the result of a force that moves an object over a distance. In physics, the mathematical equation is expressed as: Work = Force x Distance.

A claw hammer used to pry nails loose is a good example of a lever. Force is applied to the handle of the hammer. The nail represents the load, and the hammer's head is the fulcrum. The nail is closer to the fulcrum than the force, or hand. The force travels a greater distance than the load, therefore reducing the amount of effort, or work, needed to pull the nail directly out of the wood by hand.


Mechanical advantage (MA) of a lever represents the amount of increase that is gained in effort. The more mechanical advantage, the less effort is needed to perform the work. The MA of a lever is the distance of the force to the fulcrum divided by the distance of the load to the fulcrum.

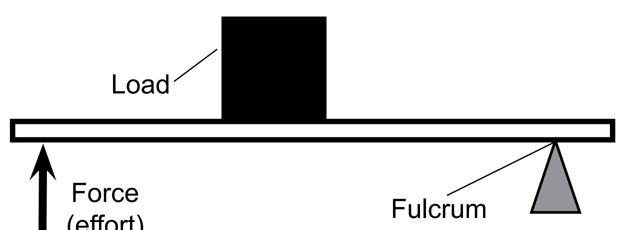
There are three different classes of levers, depending on the position of the force, the load, and the fulcrum. Each class of lever has a different application and influences force in a different way.

A first-class lever has the fulcrum between the force and the load. A seesaw on a playground is a good example of a first-class lever. If two people of equal weight sit on the seesaw the same distance from the fulcrum, the seesaw is balanced. If a heavier person replaces one of the persons, that heavier person must move closer to the fulcrum in order to give mechanical advantage to the lighter person.




**First-Class Lever**

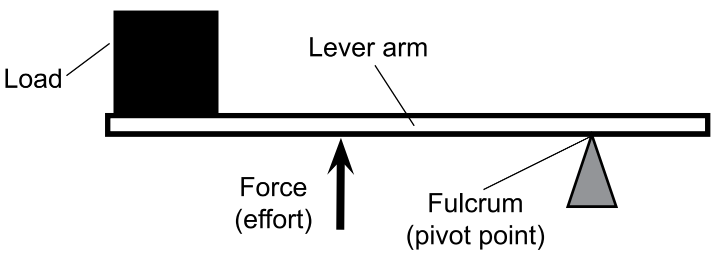
A second-class lever has the force at one end, the fulcrum at the opposite end, and the load in the middle. The wheelbarrow is a common example of a second-class lever. The person supplies the force, the wheel is the fulcrum, and the load is the material in the wheelbarrow box. Many wheelbarrows are designed with the wheel directly under the load to reduce the force required to move the load.




**Second-Class Lever**

## Levers continued

A third-class lever has the force in the middle, and the fulcrum and load are on opposite ends. A baseball bat and a broom are examples of a third-class lever. This type of lever requires the load to travel a greater distance than the force travels; as a result, the work requires more effort. Third-class levers are useful for increasing the speed at which a load is moved.




**Third-Class Lever**

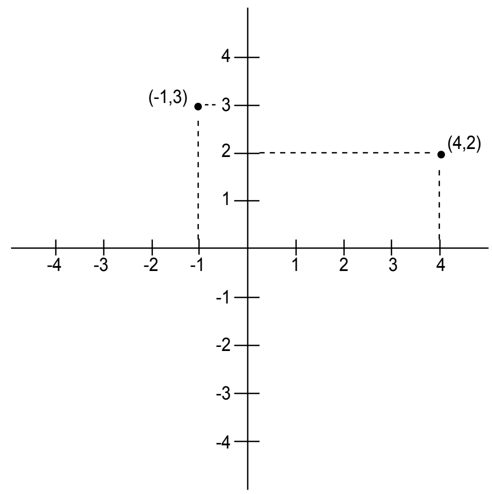
# Understanding the Cartesian Coordinate System

Cartesian relates to the French mathematician and philosopher Descartes, who, among other things, worked to merge algebra and Euclidean geometry. This work was instrumental in the development of geometry, calculus, and cartography.

In mathematics, the Cartesian coordinate system is used to determine each point in the plane through two numbers. These two points are typically referred to as the x- and y-coordinates. To define the coordinates, two perpendicular lines (the x-axis and the y-axis) are specified, as well as the unit length, which is marked off on the two axes (see example at right).

Cartesian coordinate systems are also used in space. This space, or third axis, is known as the z-axis.

Using the Cartesian coordinate system, geometric shapes (such as curves) can be described by algebraic equations.



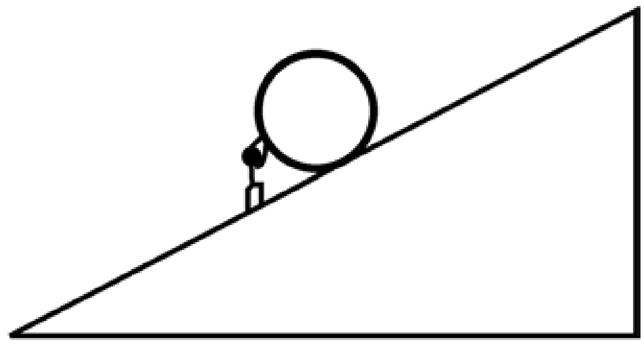

This example of the Cartesian coordinate system shows two different points, (-1,3) and (4,2), plotted.

# Simple Machines

A simple machine is any device that requires the application of a single force to perform work. They are used to help people do things that they would not otherwise be able to do.

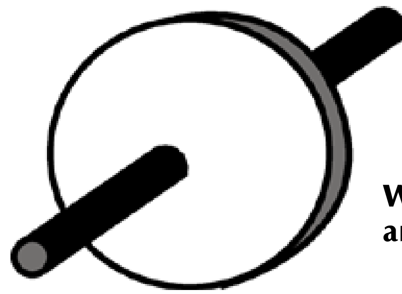
The traditional list of simple machines includes the following:

- inclined plane
- wheel and axle
- lever
- pulley
- wedge
- screw



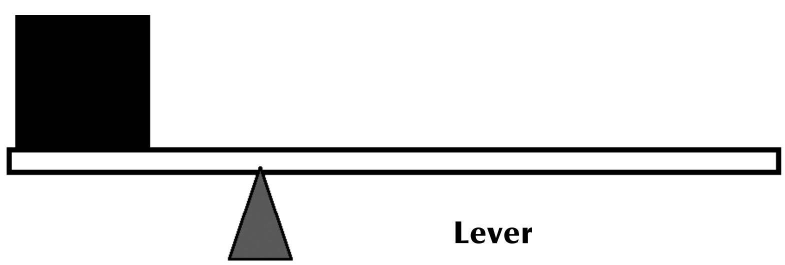
**Inclined plane**

An inclined plane is a plane surface set at an angle, other than a right angle, against a horizontal surface. Examples of inclined planes are ramps, sloping roads, chisels, hatchets, plows, and air hammers.



**Wheel and axle**

The wheel and axle consists of a wheel that turns an axle around to which a rope or cable is wound. A heavy weight attached to the rope or cable can be lifted more easily because of mechanical advantage. A wheel and axle is a lever that rotates in a circle around a center point, or fulcrum. Bicycle wheels, Ferris wheels, and gears are all examples of the wheel and axle.



**Lever**

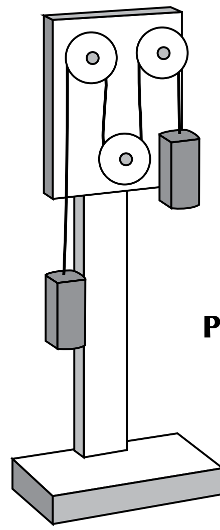
A lever consists of a bar that pivots on a point. This point is called the fulcrum. A lever is made up of an effort arm, resistance arm, and fulcrum. The closer the object is to the fulcrum, the more mechanical advantage is gained and the easier the object is to move. Examples of levers are seesaws, trebuchets, and wheelbarrows.

## Simple Machines continued

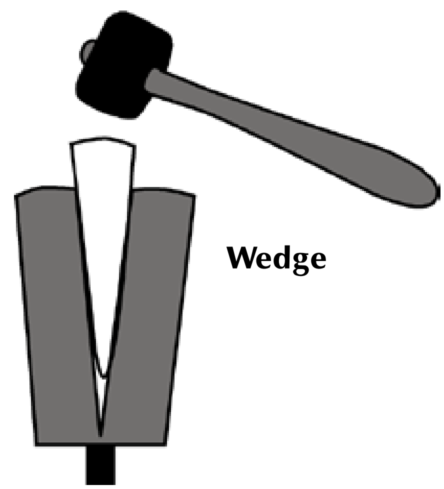
A pulley is a wheel with a groove along its edge for holding a rope or cable. Pulleys are usually used in sets designed to reduce the amount of force needed to lift a load. You can find pulleys in use on cranes and to hoist sails on sailboats.

A wedge is a simple machine used to separate two objects through the application of force. The force is applied perpendicular to the inclined surfaces of the wedge. Examples of a wedge are nails and axes.

A simple screw is a spiraled inclined plane. A screw can convert a rotational force to a linear force and vice versa. One of the most common uses of a screw is to act as a fastener that holds objects together.



**Pulley**



**Wedge**

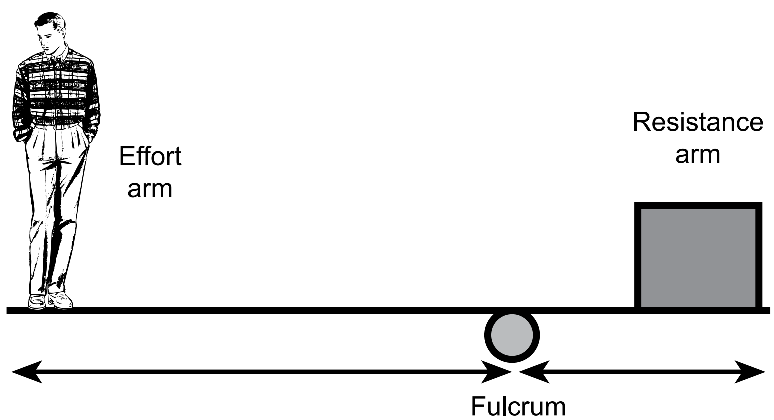
**Screw**

# Calculating Mechanical Advantage

In physics and engineering, mechanical advantage (MA) is the factor by which a machine multiplies the force put into it. Mechanical advantage can be calculated for the simple machine lever by using the following formula:

MA = distance from fulcrum to effort (effort arm)/distance from fulcrum to resistance (resistance arm/effort arm)

**2:1 Mechanical Advantage**

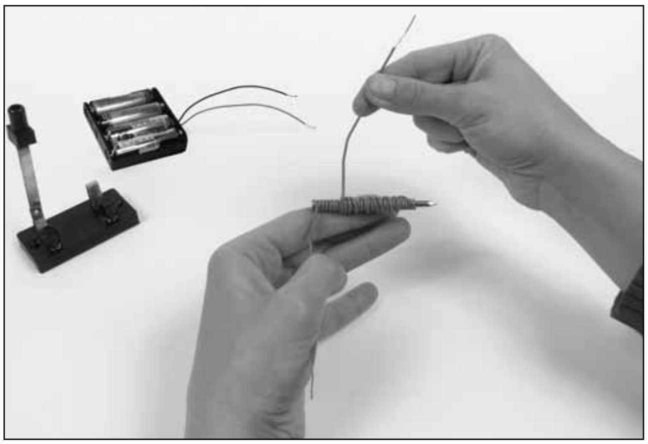



This method will result in a hypothetical mechanical advantage and can be useful for predicting the MA. However, in a real-world situation, you have to take into consideration extra force that is required because of friction. Friction is created when the fulcrum comes in contact with the lever arm. The only accurate way would be to use a spring scale and measure the effort force and load force. MA = Load Force ÷ Effort Force

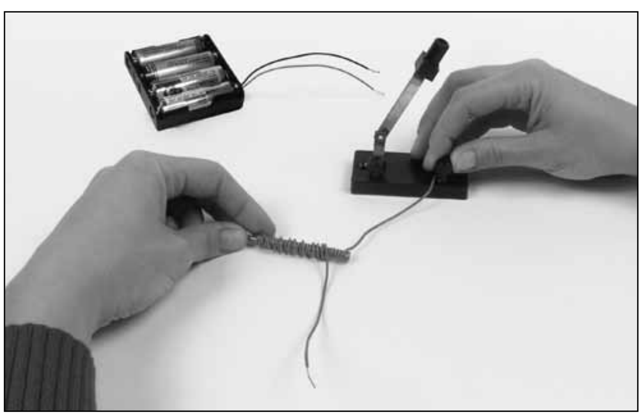
# Electromagnet

To create an electromagnet, follow these steps.

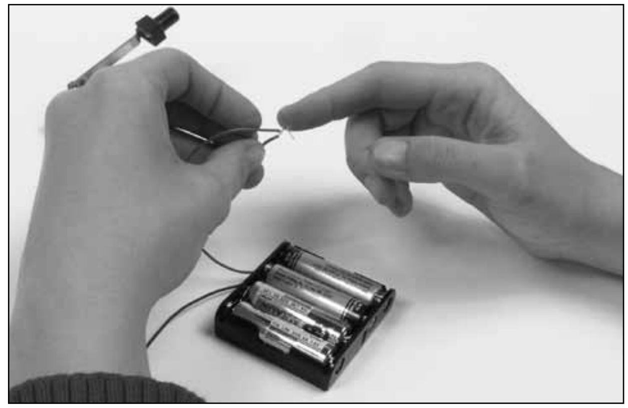
1 Wrap a wire around a nail or other metal rod (for example, a screwdriver). Leave a few inches of wire on each end.



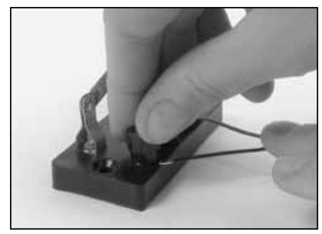
2 Connect one side of the wire to one of the terminals of a switch.



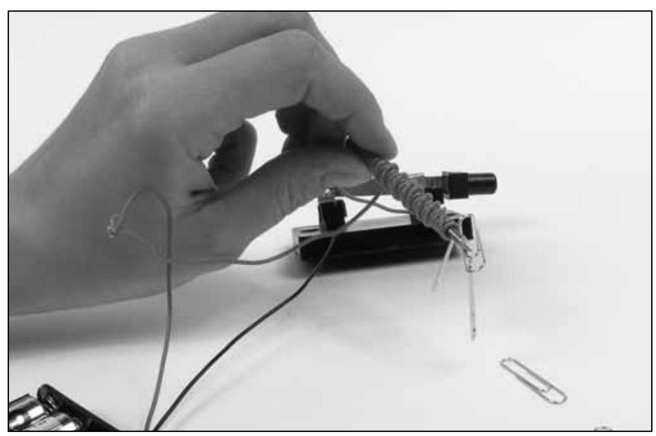
3 Connect the other side of the wire to one of the terminals on a battery. Do not overtighten.



4 Connect the switch to the battery to complete the circuit.



5 Turn on the switch. Place the nail into the paper clips. The nail attracts the paper clips.



6 Turn off the switch. The paper clips are no longer attracted to the nail.

# Additional References

To find these resources, please refer to Pitsco's *Big Book of Ideas & Solutions* catalog. To order a free copy of this catalog, call 800-358-4983.

## Books

*Junkbots, Bugbots & Bots on Wheels* by David Hrynkiw and Mark W. Tilden
*Personal Robotics* by Richard Raucci
*Building Bots: Designing and Building Warrior Robots* by William Gurstelle
*Absolute Beginner's Guide to Building Robots* by Gareth Branwyn
*BasicX and Robotics: The Art of Making Machines Think* by Chris D. Odom
*Robots, Androids, and Animatrons* by John Iovine
*Mechatronics for the Evil Genius* by Newton C. Braga
*Ultimate Robot* by Robert Malone

## Videos

*The Pitsco T-Bot II Video*
*Scientific American Frontiers: Games Machines Play*
*How Cars and Trucks are Built*
*The Great Robot Race*
*Discovery School: Understanding Robots*
*Interactions: Building a Rover*
*PDXBot.04*
*PDXBot.05*

## Web sites

http://www.pitsco.com

1-4 Label the four axes of the T-Bot II.

5 True or false: The y-axis on a Cartesian coordinate system is the horizontal axis.

6 What are the coordinates for the point on a graph known as the origin?

7 True or false: The goal of a simple machine is to lessen the amount of work needed to complete a task.

8 Provide an example of a first-class, second-class, and third-class lever.

First Class:

Second Class:

Third Class:

9 Name the six types of simple machines.

10 What is the goal of brainstorming?

1-4 Label the four axes of the T-Bot II.

5 True or false: The y-axis on a Cartesian coordinate system is the horizontal axis.

6 What are the coordinates for the point on a graph known as the origin?

7 True or false: The goal of a simple machine is to lessen the amount of work needed to complete a task.

8 Provide examples of a first-class, second-class, and third-class levers.

First Class:

Second Class:

Third Class:

9 Name the six types of simple machines.

10 What is the goal of brainstorming?

1-4 Label the four axes of the T-Bot II.

5 True or false: Mechanical advantage (MA) is the advantage gained by using one of the six simple machines.

6 What is the name for the point about which a lever turns?

A. lever
C. torque
B. fulcrum
D. axle

7 Other than the T-Bot II, provide two examples of third-class levers.

8 The hydraulic system on the T-Bot II functions by pushing on one end of a syringe filled with water that creates an equal and opposite reaction on another syringe. This concept is best related to ________.

A. the law of conservation of energy
C. Newton's second law of motion
B. Newton's first law of motion
D. Newton's third law of motion

9 Explain the difference between an automatic robot and an autonomous robot.

10 Other than the T-Bot II, provide two examples of hydraulic systems.

1-4 Label the four axes of the T-Bot II.

5 True or false: Mechanical advantage (MA) is the advantage gained by using one of the six simple machines.

6 What is the name for the point about which a lever turns?

A. lever
B. fulcrum
C. torque
D. axle

7 Other than the T-Bot II, provide two examples of third-class levers.

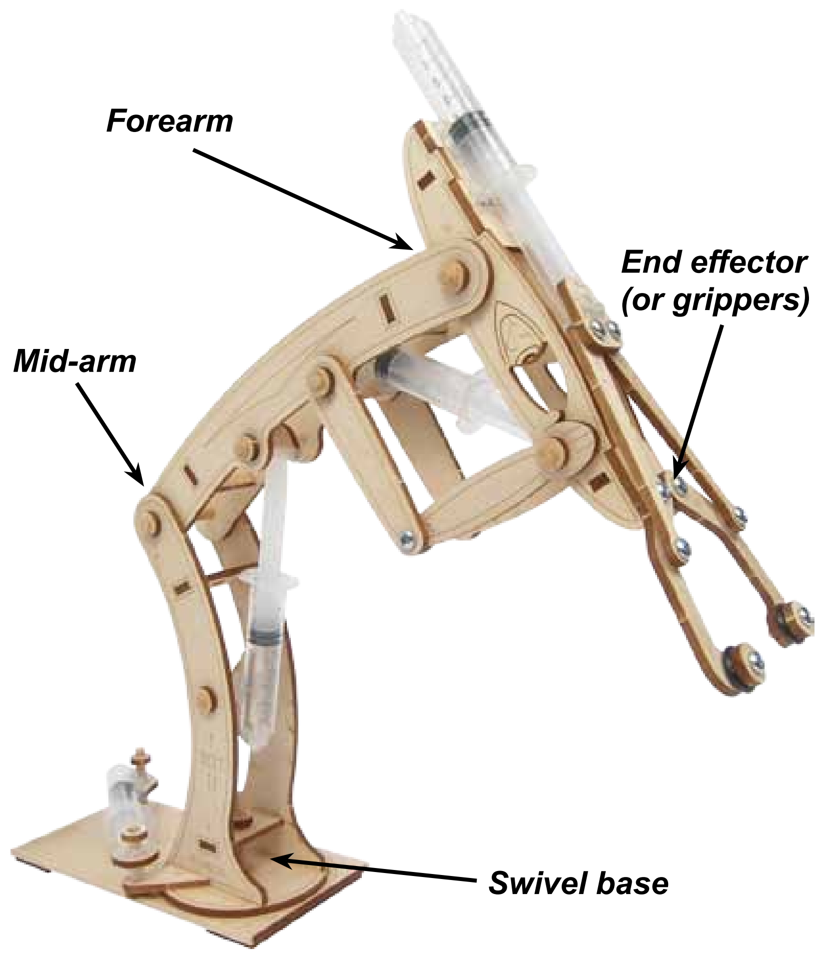
8 The hydraulic system on the T-Bot II functions by pushing on one end of a syringe filled with water that creates an equal and opposite reaction on another syringe. This concept is best related to ________.

A. the law of conservation of energy
B. Newton's first law of motion
C. Newton's second law of motion
D. Newton's third law of motion

9 Explain the difference between an automatic robot and an autonomous robot.

10 Other than the T-Bot II, provide two examples of hydraulic systems.

1-4 Label the four axes of the T-Bot II.




5 ***True*** or false: The y-axis on a Cartesian coordinate system is the horizontal axis.

6 What is the coordinate for the point on a graph known as the origin?

***(0)***

7 ***True*** or false: The goal of a simple machine is to lessen the amount of work needed to complete a task.

8 Provide examples of a first-class, second-class, and third-class levers.

First Class: ***Seesaw, crowbar, scissors, pliers, hammer, etc.***

Second Class: ***Wheelbarrow, nutcracker, nail clippers, bottle opener, etc.***

Third Class: ***Baseball bat, shovel, tweezers, food tongs, etc.***

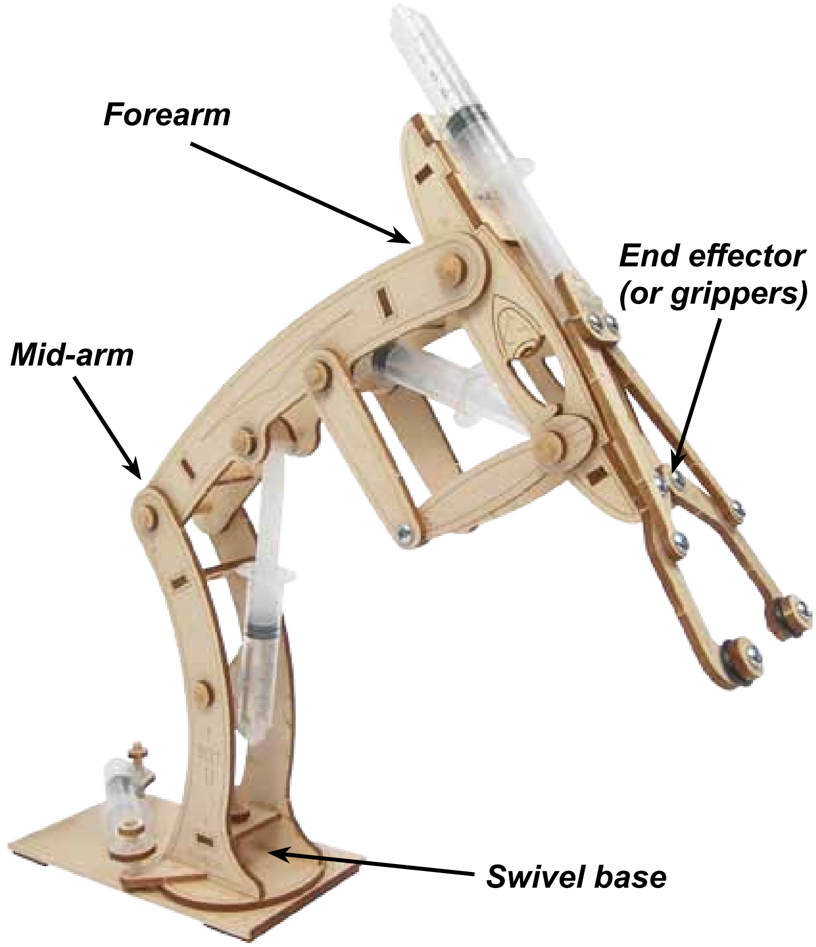
9 Name the six types of simple machines.

- ***Inclined plane***
- ***Wheel and axle***
- ***Lever***
- ***Pulley***
- ***Wedge***
- ***Screw***

10 What is the goal of brainstorming?

***To develop as many solutions to the problem as possible.***

1-4 Label the four axes of the T-Bot II.




5 ***True*** or false: Mechanical advantage (MA) is the advantage gained by using one of the six simple machines.

6 What is the name for the point about which a lever turns?

A. lever
***B. fulcrum***
C. torque
D. axle

7 Other than the T-Bot II, provide two examples of third-class levers.

***Baseball bat, shovel, tweezers, food tongs, etc.***

8 The hydraulic system on the T-Bot II functions by pushing on one end of a syringe filled with water that creates an equal and opposite reaction on another syringe. This concept is best related to ________.

A. the law of conservation of energy
B. Newton's first law of motion
C. Newton's second law of motion
***D. Newton's third law of motion***

9 Explain the difference between an automatic robot and an autonomous robot.

***automatic robots are able to perform a basic mechanical function without the help of a human; autonomous robots operate without preprogramming and human supervision***

10 Other than the T-Bot II, provide two examples of hydraulic systems.

***Car brakes, log splitters, backhoes, etc.***

# Glossary

arc length: the distance of a section of a circle or other curved figure

axes: the reference lines of a coordinate system

brainstorm: to generate creative ideas spontaneously

Cartesian coordinate system: a system designating a specific location referenced by distances from a point of origin along perpendicular axes

coordinate: the location of a point on the x-y plane – coordinates can be written as ordered pairs (x,y)

effort arm: the part of a lever on which a person or machine applies a force

electromagnet: a magnet consisting of a core, often made of soft iron, that is temporarily magnetized by an electric current in a coil that surrounds it

end effector: a device or tool connected to the end of a robot arm

fulcrum: the point or support about which a lever turns

inclined plane: the simple machine made up of a slanted, flat surface

intersection: the place or point where two things cross each other

lever: the simple machine consisting of a bar that pivots on a point called a fulcrum

origin: the point of intersection of all axes in a coordinate system

program: a set of coded operating instructions that is used to run a machine automatically

protractor: an instrument shaped like a semicircle marked with the degrees of a circle used to measure or mark angles

pulley: the simple machine that uses a rope that passes through a grooved wheel

radius: the distance from the center of a circle to its outer edge; half of the diameter

range of motion: the degree of movement possible from a joint

resistance arm: the part of the lever that is in opposition to the effort, or force

robot: any machine that can be programmed to carry out instructions and perform particular duties, especially one that can take over tasks normally done by people

screw: a spiral inclined plane

wedge: the simple machine that consists of an inclined plane with one or two sloping sides

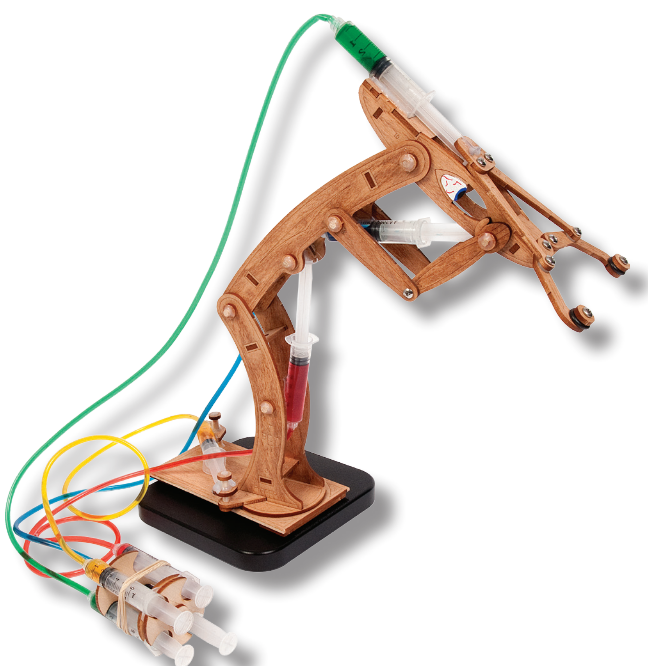
wheel and axle: the simple machine consisting of a wheel and a rod or shaft around which the wheel turns; the rod supports the wheel's center and turns with the wheel

x-axis: the horizontal axis in a two-dimensional coordinate system such as a graph

y-axis: the vertical axis in a two-dimensional coordinate system such as a graph

# T-Bot® II

***Teacher's Guide***



Call Toll-Free
800•835•0686

FreeFax
800•533•8104

Visit Us Online at
shop.pitsco.com

PITSCO EDUCATION