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ABSTRACT

This guide introduces the Craftsman/NSTA Young Inventors Award Program and includes information on competitions, science activities, and tips on how to facilitate invention programs. Sections include the following: (1) "Introducing the Craftsman/NSTA Young Inventors Awards Program"; (2) "Teaching Invention"; (3) "Young Inventors Classroom Activities"; (4) "Mechanisms--Necessary Knowledge for Novices"; (5) "Discussion Questions"; and (6) "List of Resources." (YDS)

CRAFTSMAN NSTA

YOUNG INVENTORS AWARDS PROGRAM

Teacher's Guide

3rd Edition

This booklet includes competition information, classroom activities, and tips on facilitating invention.

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Introducing the Craftsman/NSTA Young Inventors Awards Program

What is it?

The Craftsman/NSTA Young Inventors Awards Program is sponsored by Sears, Roebuck and Co. and administered by the National Science Teachers Association (NSTA). The program offers students (grades 2–8) the opportunity to win savings bonds worth up to $10,000 by inventing a new tool or modifying an existing one.

Why Participate?

The program encourages students to use their creativity, imagination and mechanical abilities, plus their science and technology background to solve problems. The program has four goals:

- To demonstrate how basic mechanical principles are applied in tool design and use
- To allow students to learn about and use hand tools
- To encourage students to think creatively about the world around them
- To encourage students to develop practical solutions to everyday problems

Experiencing the thrill of invention promotes learning for students and participating in the Craftsman Young Inventors Awards Program provides an opportunity to be involved in a national competition.

How Do I Help My Students Enter the Contest?

You can help your students by doing the following:

- Use this booklet to help introduce the scientific principles behind tools.
- Display the poster and explain the benefits of the contest to your class.

◇ Ask your students to start "Inventor's Logs" so that they can keep track of their ideas.

◇ Give the class plenty of opportunity to use all types of common hand tools.

◇ Point out that the first step to invention is identifying a problem to be solved.

◇ Sponsor your students. Every entrant must be sponsored by a teacher/advisor.

Teaching Invention

A Tool or Not a Tool...That is the Question

Take some time to discuss what a tool really is. Most students have the idea that a tool must be something heavy made out of metal, usually found in a tool box and covered with grease. A tool can be many things, but the definition that we use is the following: "A muscle-powered device that solves a problem by providing a mechanical advantage in order to do useful work."

> **"A muscle-powered device..."**—This means that the tool doesn't use any other power source except the strength of the person using it.
>
> **"...that solves a problem by providing a mechanical advantage..."**—This means that the tool must help do something useful that would be more difficult without using the tool. Mechanical advantage is defined as the ratio of output force (the amount of work done) to the input force applied to it.
>
> **"...in order to do useful work."**—Work means that the tool must actually move something, the scientific definition of work.

Which Mechanical Principles Should be the Focus of Our Work on Tools?

Many hand tools are variations of the six types of simple machines: the lever, the inclined plane, the wedge, the screw, the wheel, and the pulley. For this contest, you might focus on the lever, the inclined plane, the screw, and the wedge. Why? These types of simple machines all provide a mechanical advantage.

- **The Lever**—A lever spreads the weight of an object over a distance greater than you want to move it. The farther the person applying the effort is from the fulcrum, the easier it is to lift an object.
- **The Inclined Plane**—The inclined plane is simply a tilted surface that reduces the amount of effort needed to move something. It trades effort for distance. The steeper the incline, the shorter the plane needed, but the more effort a person must expand to lift the object. The amount of work is the same whether a person chooses to lift an object vertically or expends little effort but over a long, gently sloping ramp.
- **The Wedge**—The wedge is really two inclined planes that meet at one end to form a sharp edge or point. When pressure is applied to the wide end of the wedge, it applies an even greater pressure along its narrow end to the object being cut. The narrower the angle of the sides of the wedge, the more effectively it will transfer pressure to the narrow edge.
- **The Screw**—A screw is a combination of an inclined plane in the shape of a spiral, and a wedge. A screw is an inclined plane wrapped around a cylinder. The edges of the screw (the threads) are shaped like a wedge.
- **The Wheel**—The wheel is a modified lever that rotates around an axle, a cylinder in the center of the wheel that acts as a fulcrum.
- **The Pulley**—A type of wheel and axle, a pulley consists of a grooved wheel over and through which a rope is pulled. Pulleys are used along to make it easier to lift something by changing the direction of the force used.

Preparation for Your Invention Adventure

- **Organization and Records**—Develop a 3"x5" card box for your class. Whenever your students come up with an idea for a tool, have them fill out an "Original Thinker" card, which should include the student's name, address, date, and description of the idea. This record will help you settle any disputes among students as to who first thought of an idea. Also, you can use the cards to keep track of your students' progress.
- **Keeping Journals**—Require students to keep a journal of drawings and written descriptions of their ideas and experiments. The journals will form the basis of the students' entries, and will help students remember which ideas did and did not work successfully.
- **Environment**—Provide an environment conducive to using tools. Keep some hand tools and materials (wood scraps, nails, screws, glue, etc.) available for use. Provide the means to store students' work in progress.
- **Local Experts**—Keep a telephone directory in your room and a computer with Internet access. Encourage students to call local experts for advice and information. Professionals are almost always willing to help. Good places to start include the home improvement section of your local Sears store, the engineering departments of nearby universities, construction, landscaping, and engineering firms. You might also use the Internet to check invention-related websites.

Show and Tell

Collect a box of miscellaneous tools, including items that the students may not initially consider to be tools. Also, include items that are not tools by our definition, but which may appear to be, such as thermometers, measuring tapes, etc. One by one, allow students to decide if each object is truly a tool.

Tool ID

Have students try to identify tools used in a typical house. Ask them to conduct a "treasure hunt" at home, identifying tools used in their own homes. Most students can think of examples of how a household object was repaired using an appropriate hand tool. Ask students which tools they have personally used, and how they used them.

Levers and Checkers... Demonstrating the Distance/Weight Trade-Off

To do this experiment, students will need a #2 pencil, a 12-inch (30 cm) ruler, and several checkers. Ask the students to do the following:

- Set the ruler on top of the pencil so that it balances at the 6 inch (15 cm) mark. The pencil acts as the fulcrum for the lever, the ruler.
- Put a checker on the left side of the ruler, 3 inches (7.5 cm) from the fulcrum. Ask the students, "Where must you put the second checker to balance the ruler?"
- Add another checker to the right side of the lever. Slide the left checker outward until it balances both checkers on the right side. Ask, "Where must you put the second checker to balance the ruler?"

Other questions you can ask your students:

◇ If you had to lift a very heavy weight by pressing down on this kind of lever, would you put the weight near the fulcrum, or far away from it?

◇ Would you push down on the lever near the fulcrum or far away from it?

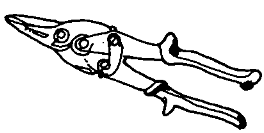
Categorically Speaking

Ask your students to place various tools in different categories based on function. Functions include:

- Pounding
- Cutting
- Prying
- Smoothing
- Making holes
- Carrying
- Leveling
- Lifting
- Measuring
- Turning screws
- Twisting
- Holding objects
- Pulling
- Cleaning
- Fastening
- Recording
- Medical uses
- Musical uses
- Toys
- Devices of or for the handicapped

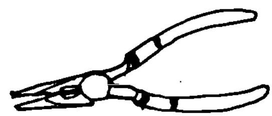
Tool Flashcards

Cut out photos and pictures of various tools. Some examples of tools you may want to use are included here. Paste these pictures on cardboard or card stock. Include the names of the tools on sheets to be cut and pasted on the back of the photos. Include the uses of the tools, which also can be pasted on the back of the tool photo. Teachers will be able to use these flashcards to teach recognition of the tool along with its name and use. Teachers can expand the quantity of tools by having students cut tools out of the Sears Sunday newspaper ads or tool catalogs. This will not only increase the number of tools available, it will allow students to recognize the actual names used by Sears for innovative tools.



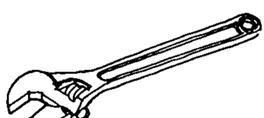
Metal Shears
snips tin and other metal

Slip-Joint Pliers
grips, pulls, or turns hard objects

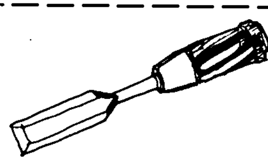


Long-Nosed Pliers
pinches, twists, and cuts wires and other small objects

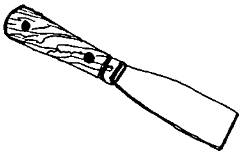
Hacksaw
cuts pipes and other metal



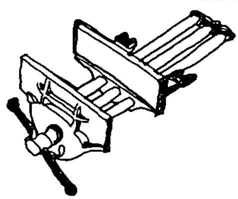
Adjustable Wrench
turns or holds nuts, bolts, or pipes



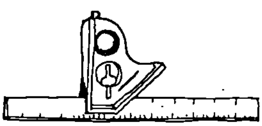
Chisel
chips, trims, and smooths wood



Putty Knife
applies, spreads, and thes pastes



Vise
holds work in place



Combination Square
levels, squares, aligns, and measures

☐ Hand Tool Chart

Ask your students to find photos and pictures of the following tools and add them to your set of flashcards:

- **Rubber-head mallet**—a soft-headed hammer used to avoid damage to the surface being struck
- **Claw hammer**—forces nails into wood, drywall or plaster
- **Crosscut saw**—cuts perpendicular to the wood grain
- **Rip saw**—cuts parallel to the wood grain
- **Coping saw**—cuts intricate curves and scrolls in wood
- **Slotted-head screwdriver**—turns screws with a single straight slot
- **Phillips screwdriver**—turns screws with a cross-shaped slot
- **Tin snips**—cuts thin metal
- **Scissors**—cuts paper, plastic, or cloth
- **Pry bar**—pries nails out of wood or walls
- **Utility knife**—cuts string, tape, screens, and dry wall
- **Brace and bit**—drills holes in wood
- **File**—smoothes and shapes wood
- **Block plane**—trims wood by shaving it with angled blade
- **Hook scraper**—removes dried paint from wood
- **Needle**—draws thread between layers of cloth
- **Shovel**—digs holes or breaks up soil
- **Pitchfork**—lifts hay, compost, and other materials
- **Pruning shears**—cuts small branches and shrubs
- **Trowel**—used to plant seed or transplants
- **Hoe**—cuts through weeds and breaks up clumps of soil
- **Rake**—collects or spreads leaves, compost or other garden material
- **Wheelbarrow**—moves heavy objects
- **Scythe**—cuts grass or tall weeds
- **Eggbeater**—used to mix air with liquid and dry food prior to cooking
- **Grater**—shreds cheese or other food into small pieces
- **Sifter**—used to mix air into dry ingredients
- **Spoon**—used to move food from one place to another
- **Rolling pin**—flattens dough or breaks up dry bread
- **Mop**—used to wash floors
- **Broom**—gathers up dirt and debris

Mechanisms—Necessary Knowledge for Novices

by L. Grant Luton

☐ Materials

- stiff cardboard or foam core, popsicle sticks, poster board, etc.
- string
- paper brads
- thumbtacks (push pins are preferable)
- bulletin board, or similar material for individual student use
- paper to cover bulletin board
- weights (any miscellaneous small objects to which string can be tied
- round plastic lids (various sizes)

☐ Tools

- ruler
- markers
- scissors
- hole punch
- hot melt glue

☐ Message to Teachers

The following outline and exercises are intended to help you and your students recognize and use various kinds of tools. These will help your students solve basic mechanical problems that they may encounter when trying to create an invention. Do not limit your exploration to just those examples that follow, but develop new activities and let your students explore on their own. Depending upon the ages of your students, you may choose to include additional vocabulary and scientific principles. Adapt this material freely to your particular classroom needs.

Students often have an idea for an invention but lack the mechanical know-how to even design, much less build, a working version of their concept. This unit is designed to assist teachers ... their students to develop some basic mechanical literacy.

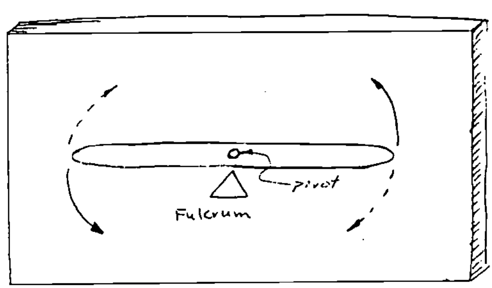
A **mechanism** is a device that changes:

◇ one *kind* of motion into a different *kind* of motion, or
◇ the *direction* of motion, or
◇ *increases* or *decreases* the *force* of a motion, or
◇ a combination of the above

Using simple objects, tools, and materials found in your classroom, you can guide your students through a series of exploratory activities that will help them discover the world of mechanisms that are a part of their daily surroundings. We will begin with one of the most basic mechanisms – and one that they will need to complete their investigations – scissors.

☐ Levers

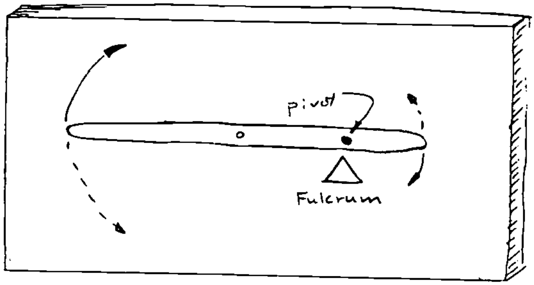
Since scissors work upon the principle of the **lever**, let's make one by cutting a strip of cardboard of any length and punching a hole in its middle. Now tack it to your board in such a way that it pivots freely without falling off. (NOTE: Any parts that are tacked directly to the board are marked "pivot".)



Observations:

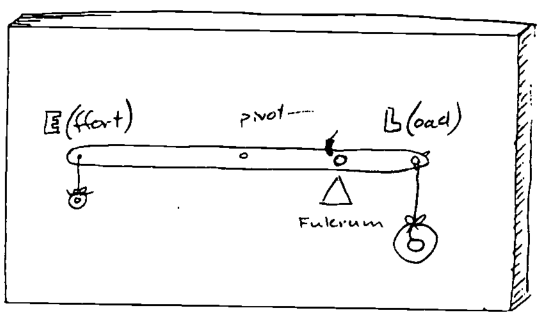
◇ The ends of the lever move in opposite directions.
◇ Each end moves the same distance simultaneously.
◇ The point at which the lever pivots is called the **fulcrum**.

Now punch a hole halfway between the existing hole and one of the ends. Place the pivot tack in this new hole and fasten it to the board.



Observations:

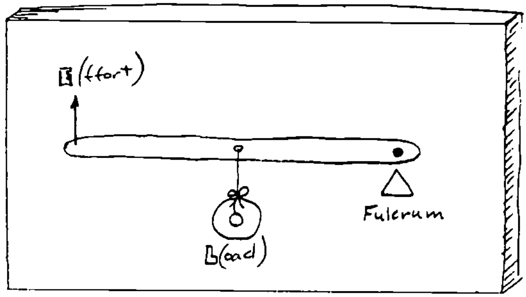
◇ The opposite ends still move in opposite directions.
◇ The long end moves faster and further that the short end.
◇ The long end moves more easily than the short end. (NOTE: This can be demonstrated by fastening various weights to the short end of the lever. I used metal washers for weights, but you can use anything from paperclips to breath mints.)



Observations:

◇ A small weight at E(ffort) lifts a heavier weight at L(oad).
◇ E moves a greater distance than L.
◇ This kind of lever is called a **Class 1 Lever** because the fulcrum is located between the **Load** and the **Effort**.
◇ Examples: crowbar, wrench, seesaw, and SCISSORS! (Place a second lever atop the first one so that they share the same fulcrum and you have a scissors action mechanism.)

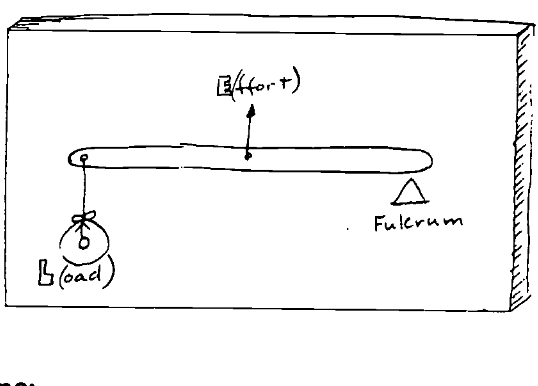
What happens when we put the fulcrum at one end of the lever instead of the middle? Let's build one and see.



Observations:

- E still travels further than L.
- This lever can be used to lift heavy objects (just like the Class 1 Lever).
- This kind of lever is called a **Class 2 Lever** because the load is located between the fulcrum and the **Effort.**
- Examples: wheelbarrow, nutcracker.

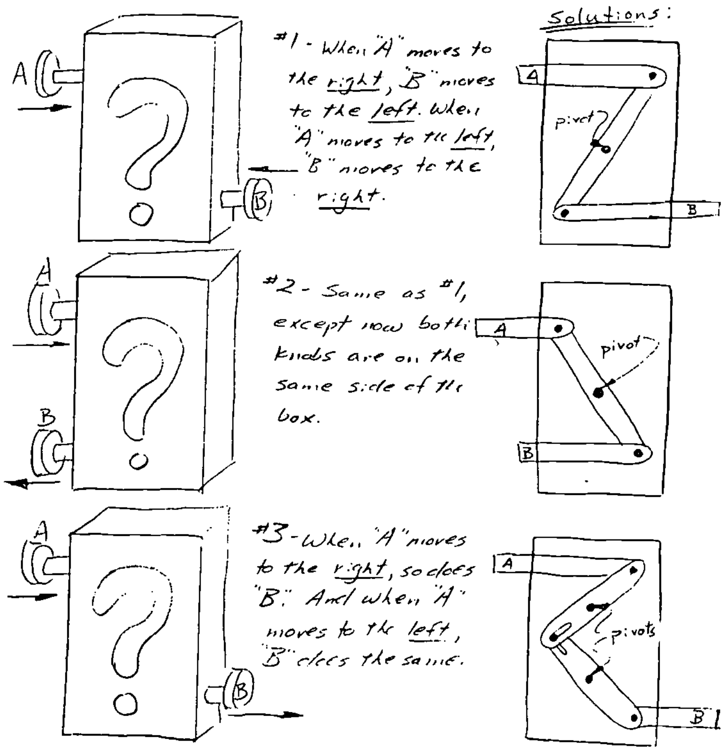
There is one more kind of lever. Let's build it by punching a third hole at the opposite end.



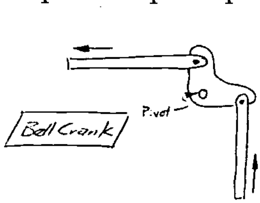
Observations:

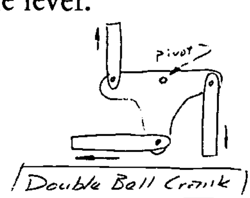
- The E(ffort) and the L(oad) now move in the same direction.
- The **Effort** must be greater than the **Load** in order to lift it. (This can be checked by experimentation using weights.)
- This is a **Class 3 Lever** because the **Effort** is located between the Load and the fulcrum.
- Examples: tweezers, shovel, elbow and forearm.

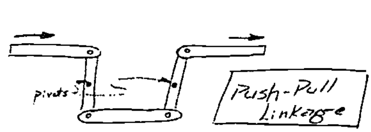
Pose some problems to your students and let them experiment with possible solutions. I call these *Black Box Problems* since the students must figure out what mechanisms are inside each box so as to allow the given **Input** to produce the **Output** shown. Possible solutions are shown at the right. (NOTE: The knobs on the ends of the end of the cardboard strips are just there for looks.)



Experiment with the following kinds of mechanisms, which are all based upon the principle of the lever.

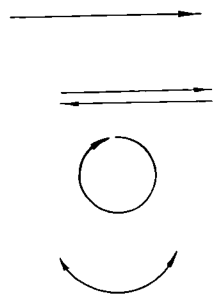






Types of Motion

There are four basic types of motion. They are:



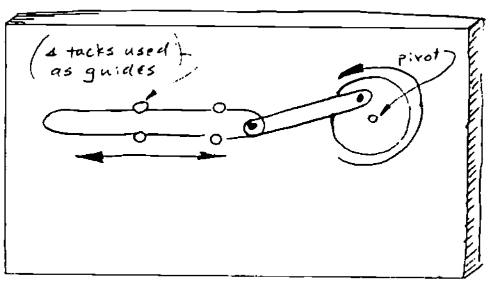
Linear:

Reciprocating:

Rotary:

Oscillating:

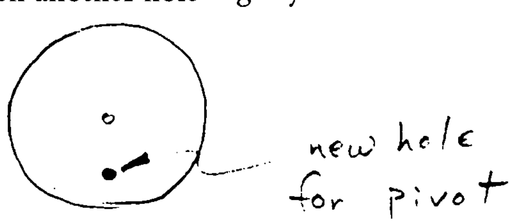
Most tools are useful in helping us convert one kind of motion into another. Here is one you may have seen on a steam locomotive. It is called a **Crank and Slider**.



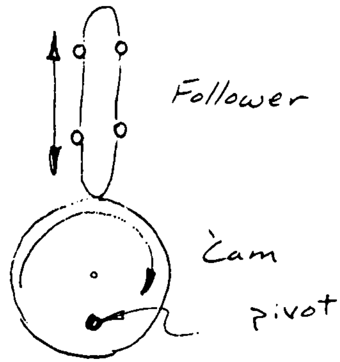
Observations:

- The **Crank** (which uses rotary motion) produces reciprocating motion in the **Slider**.
- The **Slider** can also be moved back and forth by hand (reciprocating motion) to produce rotary motion in the crank.

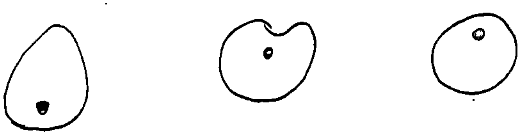
Here is another, more direct way, to convert rotary motion into reciprocating motion. Use the same disk from the crank and slider and punch another hole slightly off center as shown.



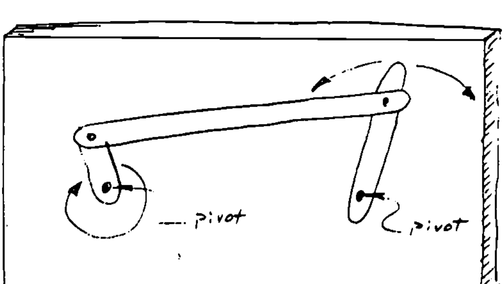
Mount the disk to your board with a tack in the new hole. Mount the strip previously used as a slider vertically above it as shown below.



Now as the disk is turned, the vertical piece moves up and down following the rim of the disk. This combination is called a **Cam and Follower.** The disk is called a **Cam** and the straight piece is called the **Follower.** Experiment with different shapes of cams so as to produce unusual patterns of reciprocating motion. Here are some possibilities:



So far, our mechanisms have used linear, rotary, and reciprocating motion; but how about oscillating? Here is a linkage that converts rotary to oscillating, and vice versa. It is called a **Treadle Linkage.**



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Continue to create new *Black Box Problems* for your students, and let them create some of their own to solve their questions (problems) and to challenge one another. Also, encourage your students to look for examples of these mechanisms in the world around them. As a result, they will find that the transition from idea to invention will be a faster and smoother one.

I hope that these playful excursions into the area of mechanisms will help provide your young inventors with some useful skills. In fact, some of these experiments may provide one of your students with just the spark of insight he or she needs to invent the next Craftsman/NSTA Young Inventors winner!

Discussion Questions

Q: What is a hand tool? How do hand tools make your life easier?

A: A muscle powered device that solves a problem by providing a mechanical advantage in order to do useful work.

Q: Are all tools complicated?

A: No. The hammer is one of the oldest tools. It was originally made of a rock tied to a stick.

Q: Can you think of tools operated by parts of your body other than hands?

A: Though the hand usually grips a tool, it could also be used with a foot or even the mouth, perhaps by the handicapped.

Q: Why do we need tools of many different sizes?

A: Tools are sized in relation to their task. For example, slotted screwdrivers come in sizes small enough to adjust eyeglass hinges, and large enough to turn a ½-inch screw.

Q: From what materials are tools made?

A: A tool can be made from any material that gets the job done. Examples include: metal, plastic, wood, and stone.

Q: Name some important tools. Now imagine a world without hand tools. How would your life be different?

A: The plow allowed civilization to develop by producing its own food source. The wheel formed the basis of transportation. Hammers, axes, and saws enabled humans to build structures.

List of Resources

As your students begin to study tools, they might find the following books and magazines useful:

Craftsman Power and Hand Tools catalog

Guide to Hand Tools: Selection, Safety Tips, Proper Use and Care.
Hand Tool Institute, 1985.

Hamilton, Katie and Gene. *The Hand Tool Companion.*
New York: Henry Holt. 1994.

Horticulture

Macauley, David. *Pyramids.*

Macauley, David. *The Way Things Work.*

Organic Gardening

Popular Mechanics

Popular Science

The World Book. Chicago: Scott Fetzer Co. 1994.
Articles on machines, wedges, screws, construction, Gardening, cooking and sewing.

Weiss, Harvey. *Machines and How They Work.*
New York: Thomas Crowell, 1983.

The National Science Teachers Association
would like to thank all those who made this booklet possible:

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for their support and contribution
to the enhancement of science education.*

To request entry materials for your classroom:

Write: Craftsman/Young Inventors
Awards Program
1840 Wilson Blvd.
Arlington, VA 22201-3000

Call: 1-888-494-4994

E-mail: younginventors@nsta.org

Visit our homepage:
www.nsta.org/programs/craftsman.asp

Entry Deadline: Mid-March each year

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