LESSON THREE: Simple Machines

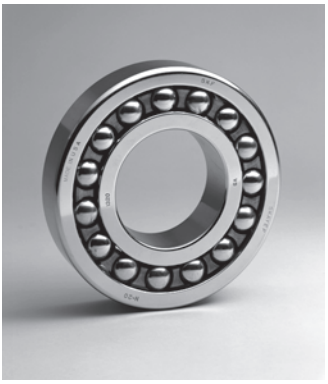

IMAGE FOURTEEN: Sven Wingquist. Swedish, 1876–1953. SKF Industries, Inc. USA. Self-Aligning Ball Bearing. 1907. Chrome-plated steel, h. 1 3/4" (4.4 cm), diam. 8 1/2" (21.6 cm). Gift of the manufacturer

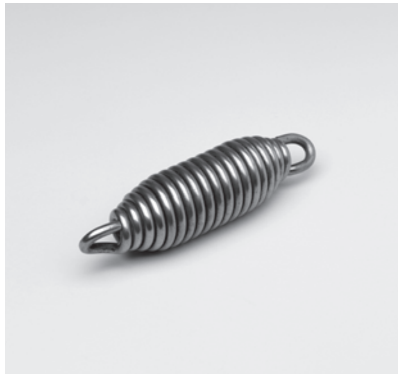

IMAGE FIFTEEN: American Steel & Wire Co., company design. American, est. 1898. American Steel & Wire Co. USA, est. 1898. Textile Spring. Before 1934. Steel, each: 9 1/4 x 2 1/4" (23.5 x 5.7 cm); beehive profile with integral loop at both ends. Gift of the manufacturer

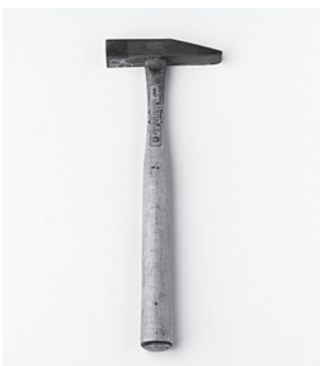

IMAGE SIXTEEN: The Stanley Works. USA, est. 1843. Stanley-Bostitch. USA, 1896. Tinsmith's Hammer. Before 1940. Steel and wood, 12 x 4 3/8 x 1" (30.5 x 11.1 x 2.5 cm). Purchase

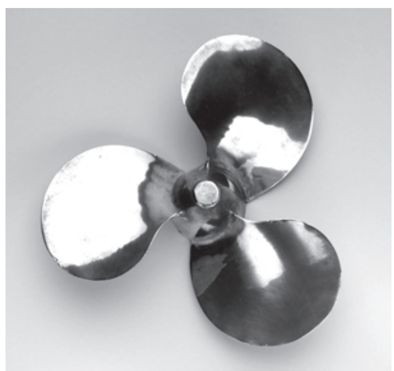

IMAGE SEVENTEEN: Aluminum Company of America, company design. USA, est. 1888. Aluminum Company of America. USA, 1907. Outboard Propeller. Before 1934. Aluminum, diam. 8" (20.3 cm). Gift of the manufacturer

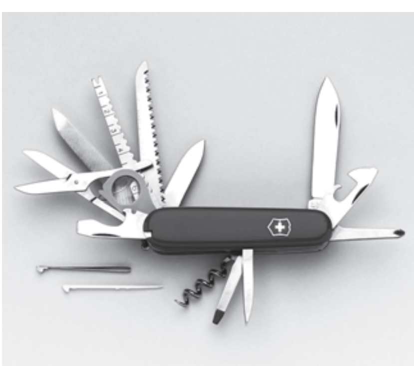

IMAGE EIGHTEEN: Carl Elsener. Swiss, 1860–1918. Victorinox. Switzerland, 1897. Golden West Merchandisers, Inc. USA. Victorinox Swiss Officers' Knife Champion (no. 5012). 1968. Plastic and stainless steel, 3 5/8 x 1 x 1 1/8" (9.2 x 2.5 x 2.9 cm). Gift of Golden West Merchandisers, USA

INTRODUCTION

At the turn of the twentieth century, many people believed that art should be available to everyone and should reflect the industrial environment, embrace mass production, and clearly show structure and materials. Designers rejected excessive ornamentation and focused on reducing nature's organic forms to basic geometric shapes.

The Museum of Modern Art was founded in 1929 with the intent of "encouraging and developing the study of modern arts and the application of such arts to manufacture and practical life." Its 1934 exhibition of design objects, *Machine Art*, surprised the Museum's audience by including a three-story display of machine-made objects such as springs, laboratory appliances, tools, and furniture. The objects were placed on pedestals, just like sculptures.

In a 1946 article titled "What is Modern Industrial Design?" Edgar Kaufmann, Jr., a curator at the Museum of Modern Art, wrote,

> In modern design, each problem is considered to carry the germ of its own solution—full comprehension of the needs to be fulfilled will indicate the form of the design. . . . The responsibility of a modern designer thus becomes understanding his problem as thoroughly as he can and solving it as directly as he can. Modern designers do not wish to overcome conditions, they wish to meet them. Functions, materials, techniques, the environment and psychology of users—these are not to be circumvented or forced, they are guides to right design.[10]

This lesson introduces students to design objects in MoMA's collection that are also simple machines, many of which were included in *Machine Art*. It looks at how these innovative machine-made objects make people's lives easier.

LESSON OBJECTIVES

- **Students will be introduced to the "machine age" and to the history of The Museum of Modern Art's design collection.**
- **Students will learn to identify simple machines and will consider how they are used in daily life.**
- **Students will consider the various elements involved in creating innovative solutions to existing problems.**

INTRODUCTORY DISCUSSION

- **Ask your students what comes to mind when they think of machines. The word is derived from the Greek *mechane* and the Latin *machina*, which mean "an ingenious device or invention." What types of machines do your students encounter in their everyday lives?**

There are many different kinds of machines. This lesson will focus on simple machines, which are tools designed to make **work** easier.

- **Ask your students if they can list six different kinds of simple machines. Make a list of their answers on the board.**

10. Edgar Kaufmann, Jr. quoted in Antonelli, *Objects of Design*, 15.

The six simple machines are a **lever**, **inclined plane**, **wheel and axle**, **screw**, **wedge**, and **pulley**. For an exploration of simple machines, ask your students to visit these Web sites:

www.edheads.org/activities/simple-machines
www.coe.uh.edu/archive/science/science_lessons/scienceles1/finalhome.htm

Complex machines are made of several simple machines. For example, a tractor is a complex machine that is made of a wheel and axle and a pulley. A can opener is a machine composed of a lever, wheel and axle, and wedge.

- **Ask your students what simple or complex machines are most helpful to them in their daily lives. Why? Can they identify some of the parts of these machines? What simple machines are they made of?**

Inform your students that they will be looking at and analyzing some machines in MoMA's collection.

IMAGE-BASED DISCUSSION

- **Show your students the Self-Aligning Ball Bearing (Image Fourteen), by Sven Wingquist and SKF Industries, Inc. Ask them to describe what they see. What do they think this is used for? Why? What simple machine parts do they notice?**

Inform them that this is a self-aligning ball bearing. It is made of steel and is composed of two layers of balls in a "race," or track. A ball bearing is used to connect two machine parts so that there is a minimal amount of friction when they slide against one another. The smooth balls roll against a smooth metal surface, "bearing" the load and allowing the two machine parts to move against each other smoothly. For example, ball bearings are what allow inline skates to roll so well.

In 1907 the self-aligning ball bearing was a new design, offering better performance and greater efficiency than older sliding bearings (which did not have balls). The new design allowed the bearing to self-align so it could adjust to misalignment during functioning without disturbing its performance. Without this tool, machine parts would have to be replaced much more frequently.

- **Direct your students through the following experiment: Ask them to rub their hands together. What do they notice? They might notice heat, caused by friction. Then ask them to put a pencil or small ball between their palms and then rub them together. Does this change the amount of heat, or friction, they feel? This is a rudimentary way of explaining how a ball or rolling object can help reduce the amount of friction between two objects.**

- **Ask your students to consider what other objects use ball bearings. How do they help the object function better? Ask your students what they think of when they hear the term "machine age."**

The ball bearing is an emblem of the machine age, a period in the 1920s and 1930s in which designers were deeply interested in the look and style of machines, and in which good design was considered to be essential to the development of society. In 1934, this self-aligning ball bearing was one of the first design objects to enter MoMA's collection. It was selected for its aesthetic qualities and for its ability to improve machine functionality.

- **Show your students the Textile Spring (Image Fifteen), by American Steel & Wire Co. Ask them what they think this spring might be used for. What different kinds of springs can they list? They may come up with the springs in pens, eyeglasses, and mattresses, a Slinky toy, or the shock absorbers on a car or bicycle.**

This is a textile spring. A spring is an object that changes its shape in response to an outside force and returns to its original shape when the force is removed. Usually, the amount of the shape change is directly related to the amount of force exerted.

- **Ask a student to "spring" across the room. The student can coil up into a ball and then jump, forcing his or her body into a straight line, then repeat this action. What do the other students notice about this action? What does the student have to do with his or her body in order to spring?**

- **Ask your students to consider how a trampoline would be different if it did not utilize springs in its design. What do the springs enable a trampoline to do?**

MoMA has many different kinds of springs in its collection, including springs used for truck safety breaks, railroad cars, and bearings. The Slinky toy is also in MoMA's collection. It is a torsion spring, or a spring without tension.

- **Show your students the Tinsmith's Hammer (Image Sixteen), by the Stanley Works Company and Stanley-Bostitch. What do they notice? What materials is it made of? What might it be used for?**

- **Ask your students to imagine what it would be like to use this hammer. What actions can you perform with a hammer?**

- **Ask your students which of the six types of simple machines this could be.**

This hammer was designed by the Stanley Works Company, which was founded in 1843 by a Connecticut businessman named Frederick Trent Stanley to manufacture door bolts and other wrought-iron tools. It can be used either as a wedge, to drive things apart, or as a lever, to pound a surface or remove nails from wood. Today the company manufactures many different tools, including screwdrivers, planes, chisels, and flashlights.

This hammer was exhibited in a 1941 exhibition at MoMA titled *Useful Objects of American Design*. It was designed specifically for a tinsmith, a person who works with tinplate, a sheet of iron coated with tin and then run through rollers. Tinsmiths have been present in America since 1720. A tinsmith learned his trade by serving as an apprentice for four to six years. He first learned to fabricate cookie cutters and pill boxes, and then moved on to make more complicated objects, such as milk pails and cake pans. Later he would create things like chandeliers. A tinsmith only needed a few tools, because he typically formed simple shapes. He used large shears, hand scissors, an anvil, and a hammer.

- **Ask your students how this hammer is different from other hammers they have seen. What are the other hammers typically used for? How does the form of this hammer relate to its function of making tin objects?**

- **Next, show your students the Outboard Propeller (Image Seventeen), by the Aluminum Company of America. Ask them to make a list of words that describe this object. What might it be used for? What type of simple machine do they think it could be? Inform them that it is a type of screw. A screw is an inclined plane wrapped around a pole that narrows toward the top. An inclined plane is a surface set at an angle other than a right angle. A ramp, water slide, and funnel are examples of inclined planes.**

This screw is a propeller. A propeller is an object with two or more blades that propels an object through air or water when spun by an engine. This outboard is designed for use on a boat.

- **Ask your students to turn to the person next to them and discuss how they think propellers might move objects. How do they work? Have some of the pairs present their ideas.**

The blades produce force. As the screw turns, water is pushed down and back. Because every force has a reaction, water moves in to fill the space left by the downward-moving blade. This results in a difference in pressure between the top (pushing) and bottom (pulling) parts of the blade. If you have a household fan, you can demonstrate this principle—the fan pulls air from the back and pushes it out the front. A boat propeller pulls water from the front and pushes it out the back.

- **This propeller is made of aluminum. Ask your students what they know about aluminum. What objects in their everyday lives are made from this material? What are the properties of this metal? Why are sodas packaged in aluminum cans?**

When aluminum was first discovered, in the nineteenth century, it was as rare and as prized as gold. Due to improved manufacturing processes, it is now common and exists in a variety of forms, all of which have the quality of lightness. Aluminum has been used in objects as diverse as airplanes, canteens, chairs, trains, bathing suits, cookie sheets, bicycles, and walkers. It is both ductile and malleable, which means that it can be pulled into thin wire and rolled into foil. It can be cast into shapes and is an excellent conductor of heat and electricity. It is difficult to corrode and has a low melting point, which makes it easy to recycle. Its surface can also accept print, which makes it useful as a packaging device.

For a design object to be acquired by MoMA for its collection, it must be both beautiful and functional.

- **Ask your students if they agree that the self-aligning ball bearing, hammer, spring, and propeller should be in MoMA's collection. Why, or why not?**

- **Show your students the Victorinox Swiss Officers' Knife (Image Eighteen), by Carl Elsener, Victorinox, and Golden West Merchandisers, Inc. Ask them if they recognize this object. What are the different components they see? What are they used for? What kinds of simple machines can they recognize?**

The Swiss Officers' Knife is known in the United States as a Swiss Army knife. This multitool model weighs only 7.4 ounces and has sixteen blades and attachments that can perform twenty-nine functions. It is complicated to make: 450 different processes are used in its manufacture. It has a lifetime guarantee, but it works so well that only one in ten thousand are returned to the factory.

The first Swiss Officers' Knife was designed in 1897 in Switzerland to replace knives imported from Germany. To distinguish the knives from copies, designer Carl Elsener placed a white cross and shield on the outside. They became internationally known when American soldiers started using them during World War II. Because their Swiss name was difficult for Americans to pronounce, the soldiers called them Swiss Army Knives.

Two companies currently manufacture these knives. The original company, Victorinox, was founded in 1884 and manufactures over twenty-two million knives and pocket tools a year, in over one hundred different models. Each model is tailored for a different user, including designs named the Huntsman, the Electrician, the Executive, and the Motorist. The older knives contained a blade, can opener, toothpick, tweezers, corkscrew, Phillips-head screwdriver, and magnifying glass. Newer models can include a USB flash drive, digital clock or altimeter, LED light, laser pointer, and MP3 player.

- **Ask your students to work in pairs to discuss what kind of tools they would include if they were designing a Swiss Army Knife for themselves. What problems would they address? Ask them to sketch their multitools.**

ACTIVITIES

Geometric beauty

The Greek philosopher Plato (c. 424–348 BC) said,

> By beauty of shapes I do not mean, as most people would suppose, the beauty of living figures or of pictures, but, to make my point clear, I mean straight lines and circles, and shapes, plane or solid, made from them by lathe, ruler, and square. These are not, like other things, beautiful relatively, but always and absolutely.[11]

MoMA curator and architect Philip Johnson used Plato's philosophy in the 1930s to explain his inclusion of machine parts in museum exhibitions. This inclusion was shocking to many people, as a museum of modern art was a very new idea, and the fact that machines were exhibited in the same museum as paintings and sculptures was revolutionary.

Ask your students draw as many basic shapes as they can, using markers or colored pencils. Then have them combine some of these shapes to create a drawing. Ask them to consider the composition of their drawings. When they have finished, lead the class in a critique. Each student should present his or her idea and then the class can discuss the work and ask the artist questions.

Tools

Ask your students to identify a problem they encounter in their everyday lives and design a tool to solve it. Their tool could be a simple machine or a combination of some of the six types of simple machines. Have them name their tool, create a sketch, list the materials, and write instructions for how to use it. Then have them present their ideas.

11. Plato, *Philebus* 51 c.