# Mercer Museum & Fonthill Castle

## Simple Machines in the Heart of the Museum

**(pre/post group visit information)**

**Mercer Museum Artifacts and Exhibits Related to Simple Machines**

The history behind humanity's development and use of tools was at the core of Henry Mercer's original interests, and was central to his collecting and research. The Mercer Museum's collection of everyday objects offers numerous practical examples of the physical and mechanical principles that served as the building blocks of modern technology. Here are some essential early American tools on display at the Mercer Museum that demonstrate how simple machine made pre-industrial life easier.

**Levers-**

Well Sweep: A counter-weighted lever used to easily raise buckets of water from a deep well. *(Level 2, Central Court)*

Butter Scale: A device consisting of two platforms suspended on a rod that pivots freely on a fulcrum. A butter scale was used to weigh butter before sending the product to market. *(Level 2, Room 3)*
Note: Many other types of balance scales are on view throughout the museum.

Scissors or Shears: Two levers working simultaneously to cut with the effort coming from the users hands. The blades of the scissors are wedges. *(Level 3, Room 19 – Tinsmith's Shears; Level 3, Room 17 – Wallpaper Shears; Level 5, Room 52 – Sewing Scissors)*

Shovel: A tool used for moving dirt, grain or other materials. The hand used closest to the scoop of the shovel is the effort and the hand farther back on the handle is the fulcrum. *(several locations, including the Mining Exhibit, Level 4, Room 33)*

Oar on Whaleboat: This paddled rod was used to propel the boat forward in the water. The load is the resistance of moving the oar through the water and the fulcrum is the oarlock. *(Level 4, overhanging Central Court)*

Handle on Blacksmith's Bellows: The effort is pulling on the handle to raise a chain or rope on the opposite end, compressing the bellows and forcing air into the blacksmith's forge. *(Level 5, Room 46)*

Pounding or Plumping Mill: The effort is applied via waterpower. Water running slowly into the scooped end of the lever fills it and adds weight which raises the pestle or pounder at the opposite end. While in this position, the water runs off the scooped end and the pestle drops into the mortar crushing the grain. The process starts again and continues as long as there is water to power the mill. *(Level 5, West Gallery)*

Handle on Grain Quern or Hand Mill: The miller's hands are on the handle providing the effort with the fulcrum being point into which one end of the handle is set. The miller pushes the handle to move the load (the stone) to grind the grain. *(Level 5, West Gallery)*

**Pulleys-**

Pulley Block: Pulleys like this were used to raise and lower materials either in or out of mines. (*Level 3, Room 33)*

**Wheels-**

Potter's Kick Wheel: This table was used by a potter to create vessels from clay. The potter pushed a disk-shaped wheel at the base of the wooden frame of the table, which established momentum and transmitted power via an axle to the turntable on top where potter worked. *(Level 2, Room 9)*

Buggies: Vehicles relied on spoked wheels for ease of movement. An axle connected two wheels that turn when pulled or pushed. *(Overhanging Central Court, Level 2)*

Square Plate Latch with Knob: This piece of 18th century architectural hardware includes an oval doorknob attached to a shaft – a wheel and axle arrangement. Turning the knob raises the latch bar and allows the door to open. *(Level 3, Room 29)*

Spinning Wheel: Tool used to twist animal (wool) or plant fibers (cotton or flax) to make thread. The large wheel is powered by a foot pedal and provided a rapid and consistent motion in order to turn a bobbin on which the fiber is actually twisted. *(Level 4, Room 38)*

Grist Mill: Powered by water, the energy transmitted by a series of gears turned the axle that connected to the top mill stone, or runner stone. The runner stone rested just above another millstone, the bed stone, which remained stationary. As the top runner stone rotated the grooves cut into both stones worked to grind the grain. *(Level 5, North Gallery)*

Great Wheel Lathe: Cranked by hand, the large wheel transferred power via a leather belt to a spinning lathe, on which a turner made cylindrical shapes in wood. *(Level 5, West Gallery)*

Blacksmith's Blower: Turning the crank drove a belt, which turned a small wheel, which in turn drove a wheel with a set of baffles, forcing air through the opening in the blower. Used instead of the larger bellows to provide oxygen to the blacksmith's forge. *(Level 5, Room 46)*

**Gears-**

Grist Mill: Powered by water, the interlocking gears worked together to turn the top runner stone that sat just above the bottom bed stone. The largest gear in the mill is called the greater face gear and is the first wheel attached to the water wheel that powers the mill. *(Level 5, North Gallery)*

Apple Parer: Used to simplify and speed up the process of peeling apples. Gears turned a shaft on which an apple was attached. As the machine was hand cranked, the gears turned the shaft holding the apple and a peeler evenly removed the skin from the apple. *(Level 2, Room 5)*

Fanning Mills: These machines were used to separate chaff (the lightweight outer husk of seeds) from grain. The gears rotated, spinning four wooden paddles to send air through the machine, blowing the chaff out the open back end and letting the grain fall below. Fanning mills replaced hand threshing methods of winnowing with baskets. *(Hanging above Central Court)*

Candy Mixing Machine: A hand-operated mixer, turned via a crank. The crank turned a wheel with teeth – a gear – which transferred energy and motion to a second gear, which rotated the mixer. The large flywheel on top helped to sustain the motion. *(Level 2, Room 14).*

**Inclined Plane-**

Charcoal Burner’s Ladder: A log that was notched to create a simple ladder. Charcoal was made by burning wood slowly and colliers, one who makes charcoal, needed a ladder to reach the top of the pile. Charcoal was used in large furnaces to extract iron from ore. *(Level 2, attached to column in Central Court)*

**Screws-**

Cider Presses: Both the beam and screw-type presses relied on a large wooden screw to raise or lower weight onto the layers of ground-up apples set between layers of straw, resting on the bed of the press. As pressure was applied, the apple juice was released and flowed to be collected. *(Level 2, Central Court)*

Lard Press: Used in a similar fashion as the cider presses, the lard press squeezed lard from large chucks of melted fat. Lard was used in cooking. (*Level 2, Room 4)*

Screw Augers: Boring tools used to make holes in wood, like a modern drill bit. Screw augers can be found in several exhibits around the Museum. *Level 5, Room 56)*

Clamp: Screws tightened or loosened the jaws of the clamp. Clamps were a tool to hold boards together for gluing, or to hold them down to a workbench. There are two types in this exhibit: hand screw clamp and cabinet maker’s clamp.*(Level 5, Room 56)*

**Wedges-**

Felling Ax: Important lumbering, land clearing, and chopping tool used extensively during America's Wooden Age, from European settlement to the mid-19th century. Wood was an abundant resource during that time and tool were used to maximize consumption and use of that resource. *(Level 3, Room)*

Pit Saw: Large two-person saw used to rip (saw lengthwise) boards out of heavy timbers. Pit saws were used with a trestle or a pit by two workers. One worker pulled up on the saw at the top while the other pulled down from below in the pit. The sharpened teeth of the saw are the wedges. *(Level 3, over hanging Central Court)*

Plow: Shaped metal wedges called the share or the moldboards of the plow, were used to break the soil and turn it over to prepare for planting. Plows could be powered by horses, oxen, or humans. *(Level 3, Room 24 – Iron Moldboard Plow; Level 4, above stairs to Level 3 – Plowman Weathervane)*

Froe: Tool used, along with a wooden club or maul, for splitting out wood shingles to cover early American buildings. *(Level 4, Room 45a)*

## *Simple Machines Vocabulary*

**Block and Tackle**: A simple machine made up of more than one pulley with a rope or cable threaded between.

**Complex or Compound Machine**: Two or more simple machines combined.

**Effort**: The force or energy put into a machine to make it work.

**Force**: A push or a pull with magnitude and direction.

**Friction**: The resistance of moving objects down when they are touching one another. Heat energy is a result of friction.

**Fulcrum:** The fixed point on which a lever pivots or turns.

**Gravity**: A force by which a planet or other body pulls objects to the center. It is the force that causes objects on earth to fall.

**Gear**: A wheel with teeth. Teeth on one gear wheel mesh with the teeth of another gear, causing both to turn. Gears can transmit power, reduce or increase force, and change the direction of a force.

**Inclined Plane**: A simple machine with a flat slanting surface that connects a lower level to a higher level. A ramp is an example of an inclined plane.

**Lever**: A simple machine made up of a stiff rod or bar that pivots on a fixed point (the fulcrum) when effort is applied.

**Load**: The object or material one is attempting to move or lift using a simple or complex machine.

**Mechanical Advantage**: The benefit gained by using machines. It is the ratio of output force to input force. The better the mechanical advantage the easier it is to do the work.

**Mechanism**: A device that changes motion, transmits power or force, or controls motion, power or force. A mechanism may consist of one or more simple machines that work together to perform functions or tasks.

**Pulley**: A member of the lever family, a pulley is a simple machine that uses a grooved wheel and a rope to move a load. A series of pulleys can be used to further lessen the effort needed to move a load.

**Screw**: A simple machine composed of an inclined plane wrapped around a pole or cylinder.

Screws hold things together, press or crush things, or move things.

**Simple Machines**: Tools or devices that make work easier (or that lessen effort). They are divided into two families: the lever family and the inclined plane family. Simple machines include the lever, wheel & axle, pulley, inclined plane, wedge and screw.

**Wedge**: A simple machine in the inclined plane family used to push things apart. Wedges have at least one slanting side ending in a sharp edge.

**Wheel and Axle**: A simple machine in the lever family composed of a disk (wheel) with a rod (axle) through the center.

**Work**: The force needed to move an object (effort) multiplied by the distance an object is moved. Work is represented with this formula: Work= Effort X Distance

**Further Exploration of Simple Machines**

- Ask students to bring to class an example of a simple machine from their house, e.g. a toy, a game, a simple (but safe) tool. Have students explain the way the machine works to their classmates.

- Classroom Exploration: Have students work in teams to identify as many simple machines as they can find in their classroom.

- Start a “Simple Machines Bulletin Board. Ask students to clip pictures from magazines of levers, screws, inclined planes, pulleys, wheels and wedges for posting.

**Activity 1-**
**Make a Wacky Machine (60 minutes+)**

*Materials and supplies required*

- recycled materials (tubes, cartons, spools, coat hangers, etc.)
- scissors
- glue sticks
- string, tape
- rubber bands
- craft sticks
- straws

*Procedure:*

1. Explain that you are going to break the group into 5-6 teams to create a wacky machine from simple and recycled materials. Each team will work in an area of the room. Show them where they can get the supplies they need.

2. Give the teams a problem that they each have to build a machine to solve. The teams will all work on the same problem though their solutions are likely to differ. Their machines can be either full-scale or smaller models of full-scale machines. The problems you give them will vary. All will be relatively simple and a little silly, e.g.: *create a machine to squeeze toothpaste onto a toothbrush, to trap a mouse, to blow out birthday candles, to empty a trash can, to help them clean their room*, etc.

3. Explain that their machine should incorporate at least one simple machine principle.

4. They will have 45 minutes to work on the machines, followed by 15 minutes to show and describe their work.

5. At the end of the time, have each group show and describe their machine.

**Activity 2**-
**Pulleys Experiment (15-30 minutes)**

*Materials and supplies required:*

- Two brooms or broomsticks
- 25 feet of clothesline rope
- pair of kid-sized gloves

*Procedure:*

1. Assign two volunteers to hold the broomsticks. Assign another one for the rope puller. Give the latter the gloves to protect his/her hands from rope burns.

2. Instruct the broom holders to stand about 5’ to 6’ apart, extending their arms towards each other with the broomsticks parallel to the floor at waist level.

3. Tie one end of the rope to the middle of one of the broomsticks.

4. Wrap the rope around the middle of the other broomstick and give the free end of the rope to the puller. The rope puller should stand so that the rope will be pulled perpendicular to the length of the broomsticks.

5. Tell the two broomstick holders to try has hard as they can to keep the broomsticks from coming together as the rope is pulled. Can the single rope puller draw the two broomsticks together? (Watch out for pinched fingers!)

6. Repeat a few more times, wrapping the rope around the broomsticks one additional time for each trial. How much more difficult is it for the holders each time? How much easier is it for the puller?

7. Ask what the students discovered. Essentially they created a pulley arrangement, with the broomsticks serving as the pulley wheels, with the rope looped around them. The load is the resistance supplied by the students holding the broomsticks. Note that the pulley has supplied the mechanical advantage. The mechanical advantage of this pulley arrangement is equal to the number of rope lengths – or the number of times the rope is wrapped around the broomsticks. The trade-off is that the rope puller must pull the rope a greater distance for each “wrap.”

    - Mechanical advantage is a ratio of output force to input force. The better the MA the easier it is to do work.

**Activity 3-**
**Levers Experiment (15-30 minutes)**

*Materials and supplies required:*

- Wide flat wooden ruler
- hexagonal (not round) pencil
- 20 - 1½” steel washers
- masking tape
- pen or marker

(Note: if you wish your students to work on this in groups as a lab activity, multiply the supplies by the number of groups you wish to have).

*Procedure:*

1. Instruct students to tear two small pieces of masking tape, write “F” for “Force” on one and

stick it on the 1-inch end of the ruler/lever. (If the ruler is both metric and "English," have students make sure they are working on the side marked in inches.

2. Label the second piece of tape "L" for "Load" and stick it on the 12-inch end of the ruler/lever.

3. Put the pencil/fulcrum under the lever at the 4-inch mark. Stack 4 washers (weights) on the Load end.

4. *Gently* use one finger to press down on the Force End of the lever/ruler to lift the load. Students should pay attention to how heavy the load feels.

5. *Carefully* stack weights one at a time on the Force End of the lever/ruler, just until the load weights at the other end are lifted up. Ask: How much force (in # of washers) was needed to lift the load?

6. Remove the force weights and slide the fulcrum under the 6-inch mark. The four load weights should still be on the Load End.

7. Repeat steps 4-6 two more times, each time sliding the fulcrum higher by two inches.

8. Discuss and explain the outcome of the experiment/activity. Note that levers help do work by trading force or effort for distance. By changing the location of the fulcrum in this activity – that is, moving it farther away from where you are applying the force and closer to the load you are seeking to move, the work becomes easier. However, the height you are able to raise the load (the distance) becomes less.

**Activity 4-**
**Wheel & Axle Windmill (15-30 minutes)**

*Materials and supplies required:*

- A piece of colored construction paper 7" x 7" square
- a long round colored pencil
- an empty cardboard milk carton (half-gallon size)
- a 12"-long piece of light string, a Life Savers™ candy
- pair of scissors
- transparent tape
- a pencil
- a ruler

(Note: if you wish your students to work on this in groups as a lab activity, multiply the supplies by the number of groups you wish to have). Have a sample of a finished windmill available.

*Procedure:*

1. Using the pencil and ruler, draw a straight line from one corner of the construction paper to the opposite corner. Draw a second line that connects the other two corners. The lines should intersect at right angles at the center. Draw a small circle, ¼" in diameter, around the center point.

2. Starting from each corner, use the scissors to cut along the lines to a point halfway between the corners and the center point.

3. Fold one free corner over so that it just touches the center circle. Tape the corner in place. Repeat this with the other three alternating corners. You should now have a pinwheel design.

4. Poke a hole through the center circle and insert the colored pencil. It must fit snugly in the hole.

5. Cut off the top of the milk carton (this could be done ahead of time as part of your preparation). Cut two slots, approx. 3/8" x 3/8," in opposite sides of the carton. Your "pinwheel" should fit loosely in and across these slots.

6. ¨Tie one end of the string to the candy. Tie the other end to the colored pencil and tie or tape it in place. Set the pencil in the milk carton slots.

7. Hold the base of your windmill and blow on the "sails." The wind from your breath should cause the sails (the wheel) to turn, which also causes the pencil axle to revolve. The turning causes the string to wind up and lift the candy. You've created a wheel and axle that does work!

**Activity 5-**
**Wedge Experiment (15 minutes)**

*Materials and supplies required:*

- A 3" x 5" index card
- Ruler
- Tape
- a piece of rigid lightweight cardboard approx. 8" x 10"

(Note: if you wish your students to work on this in groups as a lab activity, multiply the supplies by the number of groups you wish to have).

*Procedure:*

1. Fold the index card in half the short way.

2. Fold ½” of each end of the card in toward each other, overlap the ends and tape them. You should now have a small wedge.

3. Slowly push the wedge under one end of the cardboard. You may need to hold the opposite end of the cardboard to keep it from skating away. Keep pushing until you have raised the cardboard as high as possible, without it tipping back over the wedge.

4. Use a ruler to measure how far upward the cardboard moved. Compare this measurement with the distance you had to move the wedge under the cardboard. Students should find that they needed to move the wedge a greater distance to raise the cardboard a smaller distance. However the wedge gave them greater force and made their work easier.

5. Ask students to consider how wedges of different sizes would affect the results of the experiment.

**Activity 6-**
**Screw Experiment (15-30 minutes)**

*Materials required:*

- Long bolt and nut
- wide flat washer that fits on bolt
- plastic cylindrical bottle (with mouth larger than diameter of bolt)
- heavy brick or concrete block
- paper clip, wrench to turn nut

(Note: if you wish your students to work on this in groups as a lab activity, multiply the supplies by the number of groups you wish to have).

*Procedure:*

1. Screw nut onto bolt. Add the wide washer and insert the thread end of the bolt into the mouth of the plastic bottle. Washer should rest flat against the mouth of the bottle.

2. Place the bottle on its side so that its bottom rests against the brick or concrete block. Put a marker or pointer (the open paper clip) at the end of the block. This will help you to prove that you have moved the block.

3. Put your foot on the end of the bolt so that it can’t move. Use the wrench to turn the nut in the direction of the washer and bottle. The washer will push on the bottle top, causing the block to move.

4. Ask students how hard/easy it is to move the block by turning the nut. Compare this with moving the block directly by hand without the machine.

5. Note that students have again exchanged force for distance. The use of the screw made the work easier, though the force applied (hand moving the wrench) had to move a greater distance. Turning the nut put a big force on the block but moved it a very short distance, as proven by the paper clip marker.

**Bibliography and Resources for Teachers -**


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