

Simple Machines

Grade Level:

3

Total Time Required:

five or six 30-minute sessions

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Lesson Objectives:

In this lesson, students will be able to:

1. Identify and describe simple and compound machines, including examples found in nature, and apply their use to real-world tasks.

Indiana Standards:

- 3.PS.2** Identify types of simple machines and their uses. Investigate and build simple machines to understand how they are used
- 3-5.E.1** Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Next Generation Science Standards:

- 3-5.ETS1-1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Science/Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence

Crosscutting Concepts

2. Cause and effect: Mechanism and explanation.
3. Scale, proportion, and quantity.

Concepts and Vocabulary

<i>Term</i>	<i>Defined by a scientist or engineer</i>	<i>Defined by a student</i>
Simple Machine	Simple non-powered devices that change the directions of forces and motions.	Tools that make work easier.
Force	Interaction between physical bodies that create a pushing or pulling on the bodies.	A push or a pull
Work	The product of force and motion.	When a force moves an object.
Gravity	The force exerted by celestial bodies that acts to pull objects to their centers.	The force that keeps us on earth; prevents us from flying into space.
Friction	An force opposing relative motion between objects.	A force that holds back the movement of an object (i.e., skating on an ice rink vs. skating on carpet).
Incline Plane	A planar surface at an angle from horizontal.	Helps us move things higher and lower.
Screw	An inclined plane wrapped around a cylinder (round tube).	Holds things together; a long and twisted incline plane.
Wedge	Two planar surfaces at small acute angles and coming together at a sharp edge.	Splits or cuts objects.
Lever	A rigid object that rotates on a pivot point.	Moves things up and down.
Pulley	A wheel that a cord can wrap around to change direction of force.	Changes the direction of something.
Wheel and Axle	Two round objects connected by a straight rod.	Moves objects by rolling.
Gear	A set of wheels with teeth that engage and cause both wheels to rotate and transmit force.	Toothed wheel

Equipment, Materials, and Tools

Materials		
Construction paper	Push-pins	Brads
Paper/Styrofoam plates	Cardboard	Index cards
Styrofoam cups	Paperclips	Paper-towel rolls
String	Binder clips	Straws
Wooden spools	Miniature animal	

Tools		
Scissors	Pencils	Rulers

Special materials (purchase ahead of time):

- Miniature animal for the design activity: example Wolf Cub from Amazon:
http://www.amazon.com/Schleich-14606-Wolf-Puppy/dp/B0028TEO0S/ref=sr_1_22?ie=UTF8&qid=1383920488&sr=8-22&keywords=wolf+figurines

Examples of classroom-constructed simple machines:

Inclined plane – folded cardstock

Wedge – folded index card

Screw – paper wrapped around a cardboard tube

Lever – ruler on a stack of wooden craft sticks

Wheel & axle – styrofoam circles attached to the ends of a straw; wooden spools on a straw; ‘lifesaver’ mints on a straw

Pulley – string wrapped around a wooden spool on a straw

See Appendix for images of example classroom-constructed machines.

Synopsis of Engineering Design Activity

Synopsis of the Design Activity:

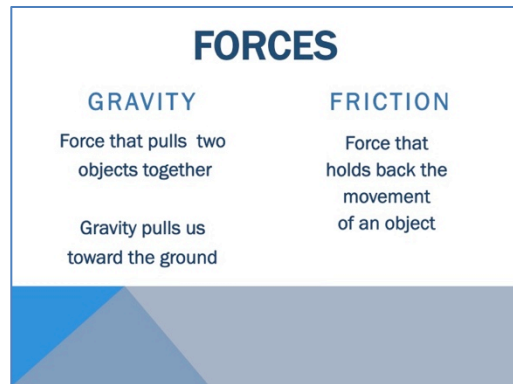
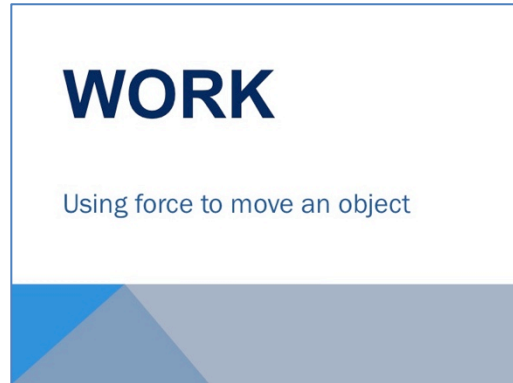
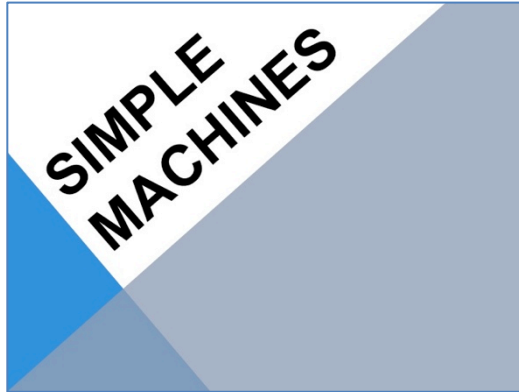
Problem:	A lone wolf has wandered into a construction zone at Purdue University and must be safely trapped and relocated to Wolf Park in Battleground, Indiana.
Goal:	Design and construct a compound machine that can safely trap and contain the wolf.
Who is the client:	Purdue University
End-User:	Staff of Wolf Park
What is the design:	Design and construct a compound machine that can safely trap and contain the wolf.
Criteria:	<ul style="list-style-type: none">• Must be large enough to hold the wolf• Should prevent the wolf from escaping
Constraints:	<ul style="list-style-type: none">• The compound machine must be composed of at least two classes of simple machines• Classroom materials will be provided for construction of the compound machine• Size of the wolf (miniature wolf figurine will be provided)



(Amazon.com)

Science Background Content

Example PowerPoint slides introducing simple machines:



LEVER
A BAR THAT PIVOTS ON A FIXED POINT

FULCRUM

the point that a lever pivots on

INCLINED PLANE
flat, sloping surface

WEDGE

2 inclined planes placed back to back.

Used to force two things apart or split one thing into two.

PULLEY

A WHEEL WITH A ROPE, CORD, OR CHAIN AROUND IT

MAKES WORK EASIER BY CHANGING THE DIRECTION OF FORCE

- few or no moving parts
- used by applying force
- make work easier by changing the amount of force needed to do the work

SIMPLE MACHINES

Lesson Plan #1: Introductory Lesson

Time: one 30-minute session

Objective: Introduce the students to the concepts of work and force.

Introduction and Group Activities:

With a partner, students will discuss what an example of work is. In whole group discussion, identify work as a use of force to move an object. This will then lead into the identification of force as a push or pull. The topics of gravity and friction may also be discussed.

Have students model moving a stack of books from the floor to a table. Ask students what would make moving the books easier (answer: simple machines!). Discuss using an inclined plane instead.

Lesson Plan #2: Inquiry Activity

Time: two or three 30-minute sessions (2 or 3 classes of simple machines are discussed in each session)

Objective: Have the students explore different options for each simple machine: real-world examples, examples from nature, classroom-constructed simple machines.

Introduction:

For each class of simple machines, three different activities are proposed in order to allow the students to

- (1) become familiar with real-world examples of simple machines,
- (2) identify examples of simple machines that are found in nature, and
- (3) be able to construct versions of simple machines using common classroom materials.

Advanced examples that identify the force and distance components that contribute to the total amount of work are included in the Appendix.

Each of the following pages contains a separate session.

Example PowerPoint slides containing the images mentioned here are available in the Appendix.

SESSION 1: INCLINED PLANE

REVIEW OF VOCABULARY:

- Plane – a flat surface (ex, a board, a desktop, a notebook, a ruler).
- Inclined – slanted, “at an angle”.
- A flat surface that is tilted at an angle so that it has one end raised higher than the other.
- Inclined planes make it easier to raise or lower a load.

1. DISCUSS AND SHOW REAL-WORLD EXAMPLES OF INCLINED PLANES:

- Identify inclined planes in the classroom, on school grounds. (ex, wheel chair ramp, stairs, door stop)
- Can students think of any others that they have seen before? (ex. Freeway entrance ramp)

2. EXAMPLES OF THE USE OF INCLINED PLANES IN NATURE:

- Images of mules walking on an inclined path to carry people up a mountain, cat ramps, ducks getting out of a pond.
- Video of penguin sliding down a hill: <http://www.youtube.com/watch?v=CkMzHGA8GgM>
- Video of wing-assisted incline running (WAIR): <http://www.youtube.com/watch?v=e81J915TEXg> Wing-assisted incline running is when a bird flaps its wings to aid in climbing a slope. Ground birds use this strategy as a way to escape danger.

3. CLASSROOM CONSTRUCTION CHALLENGE

Activity: Divide class into groups with approximately four students per group. Have each group try to come up with a list of as many examples of inclined planes as they can, and as many ways to make an inclined plane as they can think of using classroom materials.

Discussion:

1. Each group will share their ideas with the entire class. Remind the students that they will have a design and build challenge with simple machines, so brainstorming now might give them some ideas for what they can do to meet their challenge later.
2. Discuss how the angle or steepness of the inclined plane affects the amount of effort to use it.
 - Explanation: *Assume you want to get from the bottom a valley the top of a mountain. You can either take a path with the steep slope or a path with the shallow slope. The path with the steep slope is shorter (covers less distance), but require more effort (force) to walk up it. The path with the shallow slope is longer (covers a larger distance), and requires less effort to walk up it. In the end, the amount of work required to get to the top of the mountain remains the same (the height of the mountain is constant). Which would you choose and why?*
 - Can follow with a computer game developed by the Chicago Museum of Science & Industry (http://www.msichicago.org/fileadmin/Activities/Games/simple_machines/) that relates the length and steepness of an inclined plane to how much effort is expended by a person to use it (illustrated by a high vs. low level on the person’s “Force Bar”).

SESSION 2: WEDGE

REVIEW OF VOCABULARY:

- A triangular shape (ex, two inclined planes that are joined together)
- Used to split objects apart

1. DISCUSS AND SHOW REAL-WORLD EXAMPLES OF WEDGES:

- Identify wedges in the classroom, on school grounds. (e.g., scissors, push pins, etc.).
- Can students think of any others that they have seen before? (e.g., airplane wing, knife, bow of a boat, etc.)?

2. EXAMPLES OF THE USE OF WEDGES IN NATURE:

- YouTube video of kingfishers (birds) diving into water:
<http://www.youtube.com/watch?v=1CsyenHROSE>,
<http://www.youtube.com/watch?v=6YRM0sy3xIY>
- Incisor teeth on animals (ex, beaver chewing down a tree, squirrel cracking a nut open)
- Plant sprouting and pushing its way through the ground to the sun, creating cracks in the sidewalk
- A Bird wing “cutting” through the air giving the bird “lift” in order to fly.
- Tree roots pushing their way down through the ground.

3. CLASSROOM CONSTRUCTION CHALLENGE:

Activity: In a tray filled with rice, students will observe what happens to the rice as a deck of unwrapped index cards are pushed through the rice. Then students will observe what happens when a single index card is pushed through the rice. Other classroom objects may be used to demonstrate how the wedge will cut through the rice.



Discussion:

1. Wedges force objects or substances apart. When one applies force (hammer) to the large surface area part of the wedge (the head of nail), that force is then concentrated to the smaller part of the wedge (tip of nail) to do the work (entering the wood by forcing the wood fibers apart).
2. Can you give examples of when you have used a wedge this week?

SESSION 3: SCREW

REVIEW OF VOCABULARY:

- A plane that is wrapped around a central axis.
- Used to hold objects together or raise/lower objects.

1. DISCUSS AND SHOW REAL-WORLD EXAMPLES OF SCREWS:

- Identify screws in the classroom, on school grounds. (Ex, jar and lid, light bulb and socket, screws, bolts, drill bit, etc.)
- Can students think of any others that they have seen before?

2. EXAMPLES OF THE USE OF SCREWS IN NATURE:

- Pictures of beetle (Papuan Weevil) leg joints
- Hermit Crabs: <http://www.youtube.com/watch?v=tGwoOOz2s2g>; <http://www.youtube.com/watch?v=I8hZ7MM1rOg>; As hermit crabs grow, their abdomen grows into a “corkscrew” spiral shape to “screw into the shell” that they are living live in. Most shells contain a right-handed (clockwise) spiral, and most hermit crabs have a “right-handed spiral” for their abdomen. Some species of hermit crabs live in left-handed (counter-clockwise) spiral shells and have a “left-handed spiral” abdomen. As the hermit crab grows, this puts such a hermit crab at a disadvantage in the housing market as left-handed shells are less common.

3. CLASSROOM CONSTRUCTION CHALLENGE:

Activity: Construct a “cereal mover” with the class, a child-friendly adaptation of an Archimedes’ screw.

The instructions on how to build your own Archimedes Screw can be found under the blog entry “Making an Archimedes Screw at the blog “Walk Beside Me” created by Arwen Spor and Evenspor Design (<http://sporschool.blogspot.com/2010/04/making-archimedes-screw.html>, accessed 5/30/2014).

The materials you need to build your own Archimedes Screw are:

- A plastic bottle (2L or smaller)
- A dowel (such as a pencil)
- Cardstock
- A tack



Photos retrieved May 30, 2014 from <http://sporschool.blogspot.com/2010/04/making-archimedes-screw.html>.

SESSION 4: LEVER

REVIEW OF VOCABULARY:

- A movable plane or bar that rests on a second object called a “fulcrum”
- Used for raising/lowering objects

1. DISCUSS AND SHOW REAL-WORLD EXAMPLES OF LEVERS:

- Identify levers in the classroom, on school grounds. (Ex, seesaw on the playground, binder clip, broom, stapler.)
- Can students think of any others that they have seen before? (ex. Hammer’s claws, pliers, bottle opener, fishing rod, tongs)

2. EXAMPLES OF THE USE OF LEVERS IN NATURE:

- Pictures of skeletal muscles
- Levers in your body are created from your bones, joints and muscles. These levers allow you to nod your head up and down, stand on your tiptoes, and lift objects.

3. CLASSROOM CONSTRUCTION CHALLENGE:

Activity: Divide class into groups with approximately four students per group. Ask the students to sketch different ways to create a lever using common classroom materials. After discussing the ideas as a group, have the groups create one of their designs.

Discussion:

1. After the lever is built, have the students move the fulcrum to different locations and observe how the motion of the lever changes. Discuss the results as a group.
2. Can follow with a computer game developed by the Chicago Museum of Science & Industry (http://www.msichicago.org/fileadmin/Activities/Games/simple_machines/) that relates the position of the lever’s fulcrum to the total range of motion of the lever.
3. A wheelbarrow was shown as an example of a lever that is similar to the lever created by your leg and foot in order to stand on your tiptoes in a figure earlier. Is a wheelbarrow a simple machine?

Answer: Technically, if all you do is use the wheel as the fulcrum to while lifting the load in the wheelbarrow, then yes, the wheelbarrow is acting as a simple machine. However, the moment you begin to push the wheelbarrow, you are using two simple machines at the same time: a lever and a wheel and axle. This means a wheelbarrow is actually a compound machine when used correctly.

SESSION 5: WHEEL & AXLE, GEAR

REVIEW OF VOCABULARY:

- A circular object (the wheel) that is centered on a rod (the axle)
- A gear is a toothed wheel
- Used to move objects

1. DISCUSS AND SHOW REAL-WORLD EXAMPLES OF WHEELS & AXELS AND GEARS:

- Identify wheels & axles and gears in the classroom, on school grounds. (ex, wheels or a cart, door knob, gears inside a clock)
- Can students think of any others that they have seen before? (ex. Ferris wheel, merry-go-round)

2. EXAMPLES OF THE USE OF WHEELS & AXLES AND GEARS IN NATURE:

- YouTube video of salamanders and caterpillars:
<http://www.youtube.com/watch?v=HmLS2WXZQxU>
- YouTube video of spiders: <http://www.youtube.com/watch?v=V4odlo0Afjs>
- YouTube video of leaf-hopper legs (gears):
<http://www.youtube.com/watch?v=cq0Mf2pt2XA>
<http://www.youtube.com/watch?v=deoEDaEto8Q>
<http://www.youtube.com/watch?v=kQ7O10E3eFk>

3. CLASSROOM CONSTRUCTION CHALLENGE:

Activity: Divide class into groups with approximately four students per group. Ask the students to sketch different ways to create a wheel & axle using common classroom materials. After discussing the ideas as a group, have the groups create one of their designs.

Discussion:

If you move an object by pushing it, you must overcome the force of friction to start to move it. Once the object has started moving, friction (the force) still opposes your efforts to push the object (the force you apply to the object). Wheels and axles make objects easier to transport from one place to another by reducing the friction involved in moving those objects.

SESSION 6: PULLEY

REVIEW OF VOCABULARY:

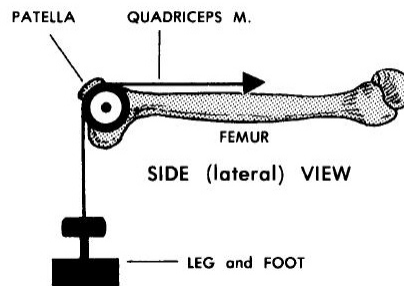
- A grooved wheel on an axle that is created to allow movement of a rope, a belt or a cable along its edge
- A pulley changes the direction of a force
- Used to raise/lower an object or to change the direction of motion of an object

1. DISCUSS AND SHOW REAL-WORLD EXAMPLES OF PULLEYS:

- Identify pulleys in the classroom, on school grounds. (ex, flagpole, window blinds)
- Can students think of any others that they have seen before?

2. EXAMPLES OF THE USE OF PULLEYS IN NATURE:

- The human knee acts as a pulley where the “rope” is the tendon connected to your thigh muscle (quadriceps) that slides over a round surface at the end of the thighbone (the “wheel” is at the end of the femur) at the kneecap (patella). The knee is the pulley that changes the direction of the force from contracting your thigh muscle so that you can straighten your leg.



(Source of image: <http://armymedical.tpub.com/md0006/md00060098.htm>)

3. CLASSROOM CONSTRUCTION CHALLENGE:

Activity: Divide class into groups with approximately four students per group. Ask them to build a pulley system to pass messages to a classmate seated across the room using common classroom materials. Note: A successfully designed system could have pencils through centers of thread spools and held by students at different parts of the room, ends of string tied, string looped around spools, message written on note clipped/pinned/taped to string.

Discussion:

1. Can you think of other situations in which this style of pulley system would come in handy?
 - A clothesline?
2. How could you send the same message to more places in the room?
 - Add additional kids holding more ‘pulleys’, but using same circular string wrapped around all pulleys to alternatively configure the pulley system into a triangle, square, etc.

Lesson Plan #3: Design Challenge - Save the Wolf!

Time: two 30-minute sessions

Objective: To safely capture a wolf who has wandered into an unsafe area

Procedures:

1. Distribute, read aloud, and discuss the design brief. Ask the following:

What is the problem?

Who is the client?

Who is the user?

What are the criteria?

What are the constraints?

What materials and tools have been provided?

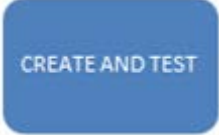




IDENTIFY PROBLEM

2. Have students respond to the above questions in their notebooks. Discuss responses with class.
3. Review with the students
- Show the students the materials that are available for the activity.
 - Remind students to use the materials and skills learned from the inquiry sessions to solve the problem.
 - Have the class list the simple machines introduced in the previous session and an example where each machine is used for common tasks.
 - Review the concept of Compound Machines - a device that combines two or more simple machines in order to make work easier.
 - Example: can opener
 - Show the students an example from Rube Goldberg (see Appendix)
 - Demo: the Mousetrap board game
 - Movie clip from *Hotel for Dogs* (see Appendix)
4. Instruct students to individually brainstorm ideas and apply what they have learned about:
- Simple machines and the motions associated with each machine
 - The available resources (tools, materials, time), criteria, and constraints.
 - Alternative methods/machines to accomplish the design tasks
5. Have students list or sketch their own ideas in their notebooks. Then have them choose their best idea to use as an individual design plan. Remind students that sketches should be large, neatly drawn, and clearly labeled showing dimensions and materials.
- Encourage students to dissect the problem into tasks that need to be accomplished in order to safely relocate the wolf.



SHARE AND
DEVELOP A PLAN

- b. Ask the students to consider which simple machines might be utilized to accomplish each task (multiple machines might be required, and/or several machines could be chosen to accomplish the same task).
6. Students should then meet with their team and share plans, explaining how they expect their design to solve the problem. Each team should decide on a ‘final’ group design, which can be a combination of ideas or a specific design from an individual within the group. Have each team member sketch the final design. Each of the students’ sketches should be detailed to allow anyone else to construct the design by looking at the drawing.
7. Student teams will construct their design. 
8. Test the design when completed, taking notes about what is working well and what could be improved.
9. Each group presents their design to the whole class and then demonstrates their prototype for the class. 
10. After all groups have presented, each student will answer the following questions in their notebook:
 - *How effective (good) was your design? How do you know?*
 - *What would you change in your design? Why?*
11. If time permits, encourage students to redesign based on test results. If time does not permit, instruct students to sketch a new design in notebook based on change mentioned above. Remind students to note any changes if design is modified from the original sketch. 

Assessment

The following are possible sources of formative and summative assessment:

From Lesson Plan #3, use a simple rubric to assess student notebooks for the following Design Process Standards:





















- Identify a need or problem to be solved.
- Document the design throughout the entire design process. (individual, group, redesign sketches)
- Create the solution through a prototype.
- Evaluate and test the design.
- Communicate how to improve the solution.

Individual participation within group

- Note level of engagement
- Ability to work well with other team members during design process
- Contribution during team presentation

See example rubrics on following pages.

	Includes a few details. 1	Includes some details. 2	Includes many details. 3
Problem			
Goal			
Client			
User			
Criteria			
Constraints			
Individual Design			
Group Design			
Sketch			
Reflection			

Problem		
Goal		
Client		
User		
Criteria		
Constraints		
Individual Design		
Group Design		
Sketch		
Reflection		

Name _____ Design Task _____
 Teacher _____ Date _____

	5	4	3	2	1
Identified each step of the design process (problem, goal, client, user, criteria, constraints)	Correctly identified 6 steps of the design process	Correctly identified 5 steps of the design process	Correctly identified 4 steps of the design process	Correctly identified 3 steps of the design process	Correctly identified 1 or 2 steps of the design process
Individual Design (sketch includes measurements, labels, different viewpoints, materials)	Individual design fully explained	Individual design includes 4 or 5 of the requirements	Individual design includes 2 or 3 of the requirements	Individual design includes only 1 of the requirements	Individual design not included
Group Design (sketch includes measurements, labels, different viewpoints, materials)	Group design fully explained	Group design includes 4 or 5 of the requirements	Group design includes 2 or 3 of the requirements	Group design includes only 1 of the requirements	Group design not included
Applied Knowledge	Applied what was learned to a successful design	Considered many ideas that were learned to make a successful design	Considered some ideas that were learned to make a successful design	Considered few ideas that were learned to make a successful design	Did not consider ideas that were learned to make a successful design
Reflection What I did, What worked well, What didn't work well, What I would change, What I learned	Reflection answered all questions	Reflection answered 4 of the questions	Reflection answered 3 of the questions	Reflection answered 2 of the questions	Reflection answered only 1 of the questions

	3	2	1
Participation	I participated in all parts of the design process with my group	I participated in most of the design process with my group	I did not help my group much with the design process
Cooperation	I respectfully cooperated with all members of my group	I was cooperative part of the time	I did not cooperate well with my group members
Presentation	My presentation was clear and showed what I know about the design process	My presentation was somewhat clear or did not fully explain the design process	My presentation was not clear or did not show an understanding of the design process

Design Activity

Save the Wolf!



A gray wolf has wandered into an active construction zone on the campus of Purdue University. The construction zone is not a safe place for the wolf. Purdue decides to hire the staff of Wolf Park to safely capture and move the wolf from the construction zone to their park in Battleground, Indiana.

As a staff member of Wolf Park, you and your team must **design a compound machine to safely capture the wolf**. The machine must be large enough to comfortably contain the wolf and should prevent the wolf from escaping. The machine should be made from at least two classes of simple machines (lever, pulley, wedge, inclined plane, wheel/axel, screw) and should be constructed from the materials provided.



<http://wolfpark.org/animals/info/wolves/>

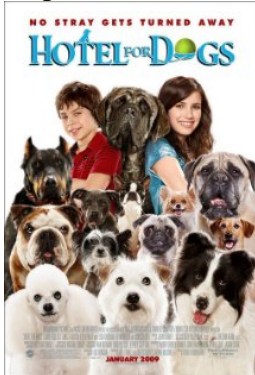
APPENDIX: Lesson Extensions and Resources

Activities:

- Connections can be made to Wolf Park in Battle Ground, IN (<http://wolfpark.org>), potentially involving a field trip.
- The Children’s Museum of Indianapolis has a “Construction Site” exhibit that allows students to explore different types of simple machines. (<http://www.childrensmuseum.org/scienceworks>)
- Every spring, Purdue University hosts a regional Rube Goldberg Machine Contest (<http://rubegoldberg.com>). This event is free and open to the public. The machine must perform a simple task (e.g., screw in a light bulb) in 20 or more steps. This website contains many videos showing the different machines as well as information for creating a team (i.e., starts at the middle school level).

Video clips or movies:

- Bill Nye the Science Guy clips on YouTube about simple machines
- Clips from Hotels for Dogs (2009)



DreamWorks (USA)

Interactive websites:

Edheads™ Simple Machines

<http://www.edheads.org/activities/simple-machines/>

An interactive environment for students to learn to identify simple machines and to identify the different simple machines that makes up a compound machine. All the six classes of simple machines are described, and the examples are very thorough. It includes interesting graphics and storyline. Sound effects are very good too.

Chicago Museum of Science and Industry – Simple Machines Game

http://www.msichicago.org/fileadmin/Activities/Games/simple_machines/

This is an excellent interactive computer game for students once they have a basic introduction to the different classes of simple machines. It has interesting graphics and storyline. Game goes through different examples of simple machines, including good ones and not so good ones (for example, an inclined plane that is too steep). It has a qualitative “Force Bar” that can illustrate the amount of force or work required to use each simple machine. For example, an

inclined plane that is very short and steep requires a lot of force to use whereas a plane that is longer and less steep requires much less force and is therefore easier and better to use.

iPad application:

Kids Discover Simple Machines (vol. 6) \$3.99

This is an interactive app that describes real-world examples and uses of simple machines. For examples, students can click on different parts of a car to learn about the different simple machines (for example, the steering wheel is a wheel & axle). Another nice feature is a fully illustrated Rube Goldberg cartoon showing the 19 steps it takes to sharpen a pencil (involving a smoking iron and an opossum). There are also some interactive activities and a quiz. Good graphics and interface. Some concepts may be too advanced for 3rd grade students (ex, includes discussion of the Egyptians and the Roman Army building ramps). Certainly a very good “refresher” for teachers and provides some useful examples of simple machines that might not be obvious (ex, wind turbine as a screw, nutcracker as a lever).

Books:

Simple Machines series, by Kay Manolis, 2010 (621.7, 621.8): *Screws, Wheels and Axels, Ramps, Levers, Wedges, Pulleys*

Inclined Planes and Wedges, by Sally M. Walker and Roseann Feldmann, 2002 (621.8)

Janice VanCleave’s Machines: Mind-boggling experiments you can turn into science fair projects, by Janice VanCleave, 1993 (621.8)

Websites related to Rube Goldberg:

Short Biography

<http://www.rube-goldberg.com/>

DIY Rube Goldberg Machines

<http://www.youtube.com/watch?v=dFWHbRApS3c>

Purdue Rube Goldberg Machine claims Guinness World Record

http://www.youtube.com/watch?v=xdPDn1KUz_A

OK Go “This Too Shall Pass”/Rube Goldberg Machine

<http://www.youtube.com/watch?v=qybUFnY7Y8w>

GoldieBlox Rube Goldberg Machine ‘Girls’ Commercial

<http://www.youtube.com/watch?v=8i8IXBC7QTI>

Honda Commercial

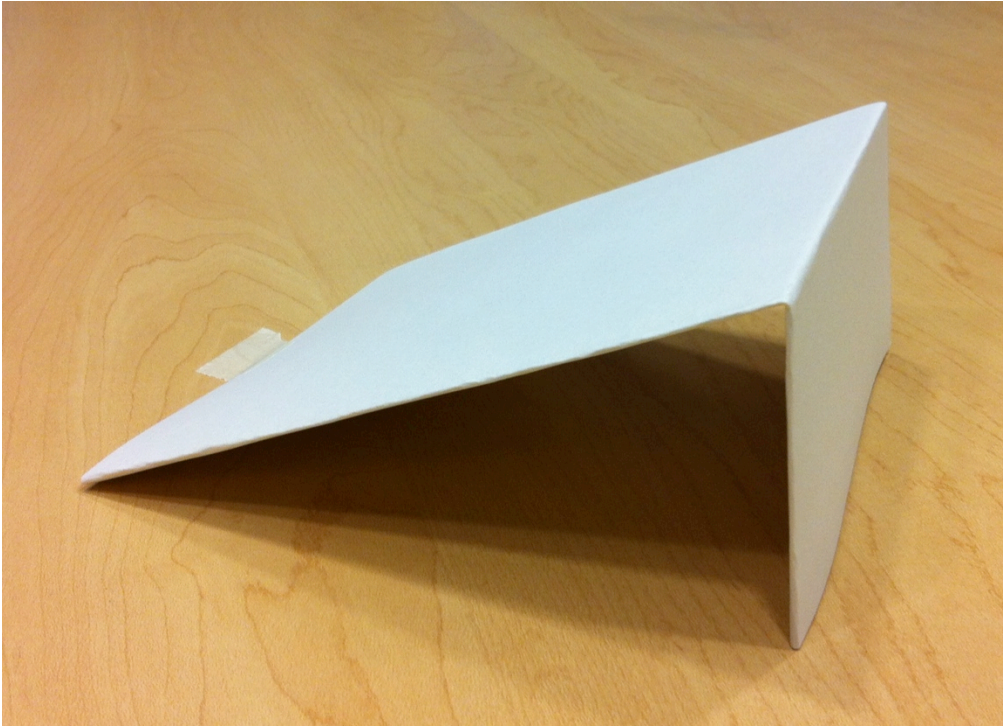
<http://www.youtube.com/watch?v=YWk9N92-wvg>

London Science Museum

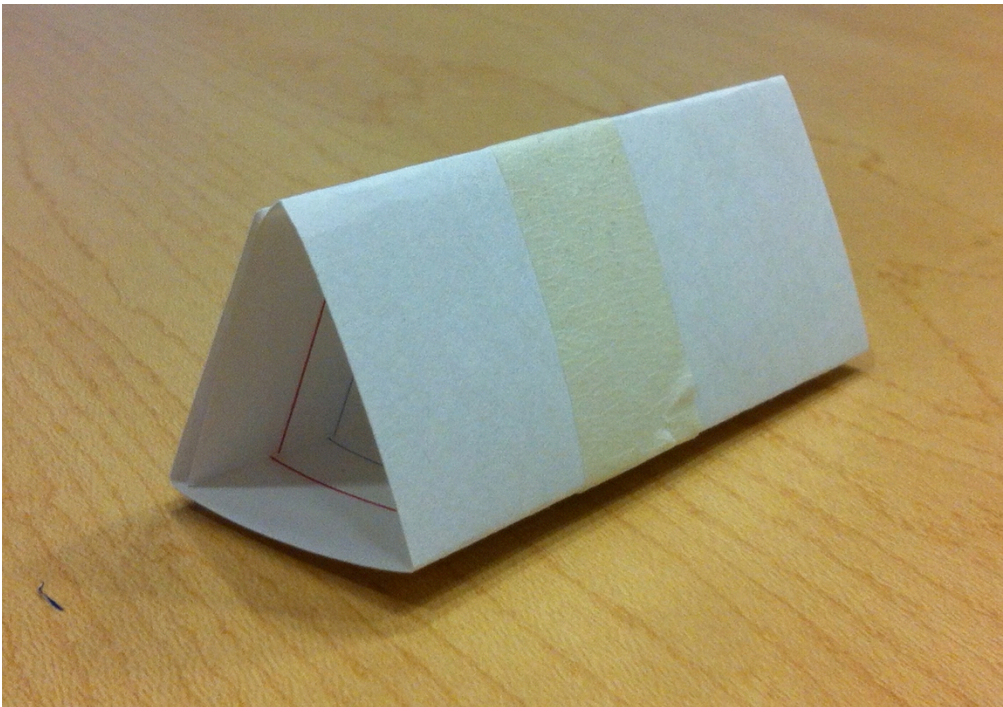
<http://www.youtube.com/watch?v=JmnRJ2M4eik>

Images of Classroom-Constructed Simple Machines

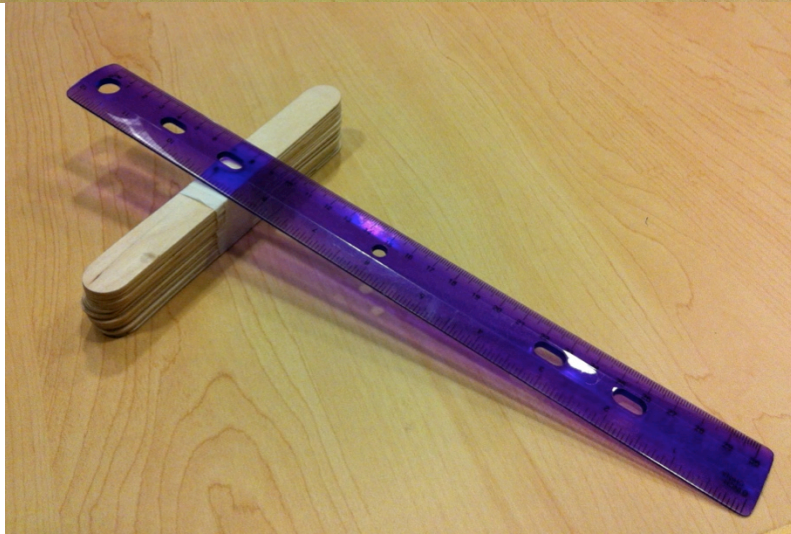
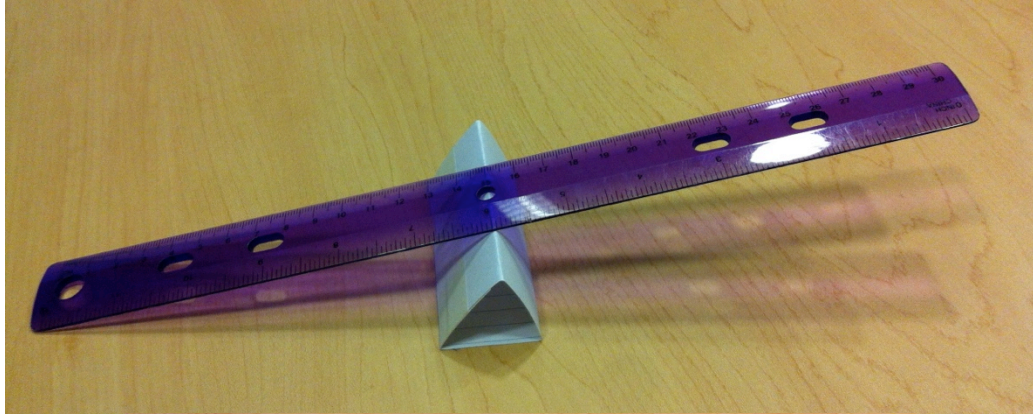
Inclined plane – folded cardstock



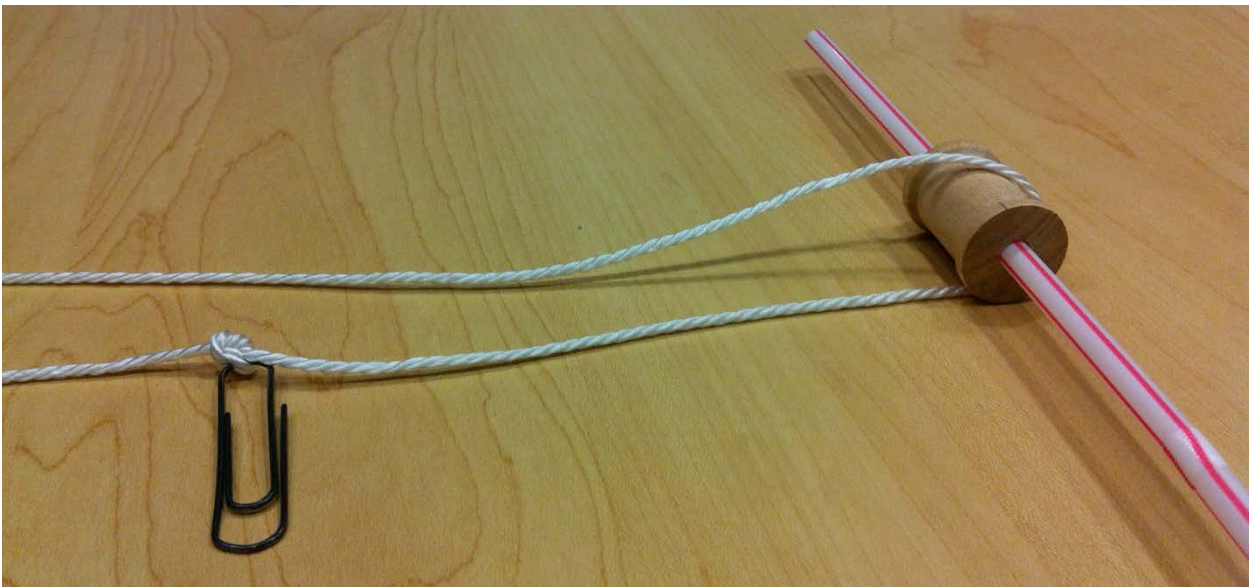
Wedge – folded index card



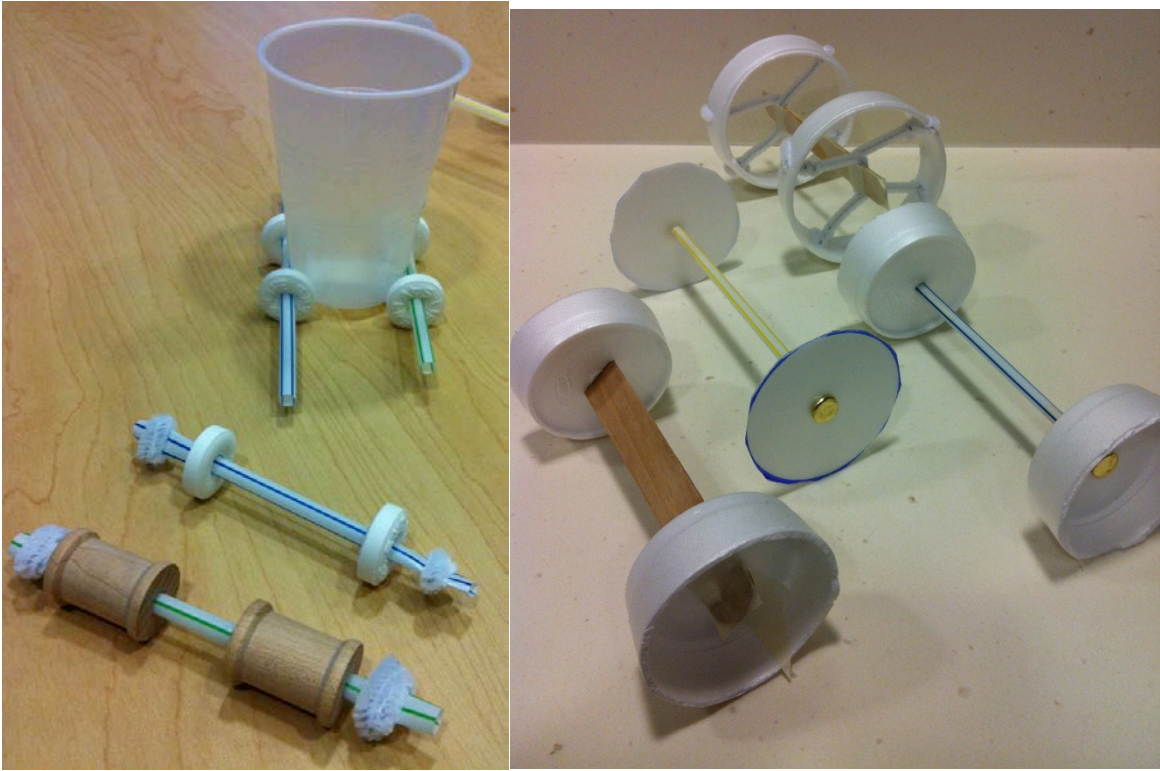
Lever – ruler on a stack of wooden craft sticks



Pulley – string wrapped around a wooden spool on a straw



Wheel & axel – styrafoam circles attached to the ends of a straw; wooden spools on a straw; 'lifesaver' mints on a straw



Inquiry Lesson Extensions:

Simple machines make work easier.

$Work = Distance \times Force$

Distance: length of space between two points, objects or places

Force: the effort (strength or energy) needed to cause motion or change. Forces only exist during the interaction of one object with a second object.

Examples:

- *Inclined planes:* children running (the force) up (the distance) a ramp (the inclined plane) to get from the first floor to the second floor at a museum. (Running up a ramp is easier/less work than climbing straight up a ladder!)
- *Wedges:* A farmer using a shovel (object 1) to dig (the force) potatoes (object 2) out (the distance) of the ground. A lumberjack swinging (the force) an ax (object 1) to split (the distance) a log (object 2) in two.
- *Screws:* A carpenter using a screwdriver to turn (the force) a screw to connect (the distance) a door handle (object 1) to a cabinet (object 2). Twisting (the force) a lid (object 1) to remove (the distance) it from a jar (object 2).
- *Levers:* A boy (object 1) and a girl (object 2) going up and down (the distance) on a seesaw (the lever) in a playground. A girl lifting (the force) the end of a bottle opener (the lever) to pry off (the distance) a bottle cap (object 1) from a soda bottle (object 2). Using a tweezers (the lever) to pull (the force) a sliver (object 1) out (the distance) of your finger (object 2).
- *Wheel & axle:* A mother (object 1) pushing (the force) a grocery cart (object 2) from the store to her car (the distance). Oxen (object 1) pulling (the force) a covered wagon (object 2) filled with a family and all of their possessions from Missouri to Oregon on the Oregon Trail (the distance).
- *Pulleys:* A crane lifting (the force) construction materials (object 1) off (distance) of the ground (object 2) using pulleys and cables. A pirate using block and tackle (system where two or more pulleys have a rope threaded between them) to raise (the force) a sail (object 1) to the top (distance) of the mast (object 2).

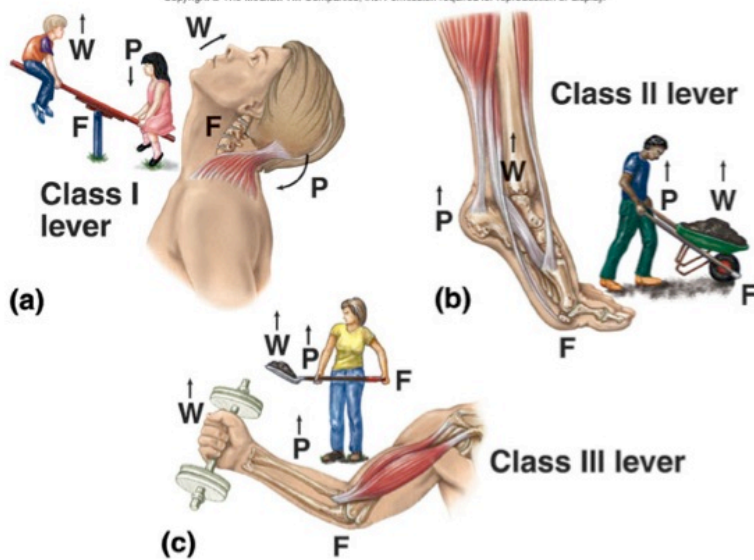
SLED Design Project: Simple Machines

Simple Machines, Examples from Nature

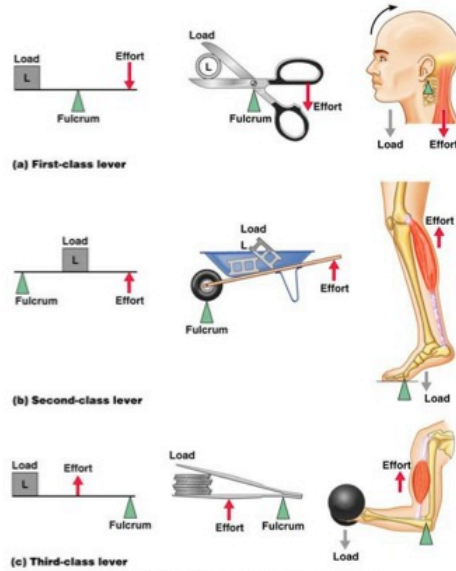
The Lever

Your skeletal muscles work as levers to move your body.

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The Lever



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

Figure 10.3



The Wheel and Axle

Salamanders and Caterpillars, oh my!

<http://www.youtube.com/watch?v=HmLS2WXZQxU>

<http://videosift.com/video/Nature-invented-the-wheel>

And Golden Wheel Spiders, too!



<http://www.youtube.com/watch?v=V4odlo0Afjs>

The Wheel and Axle

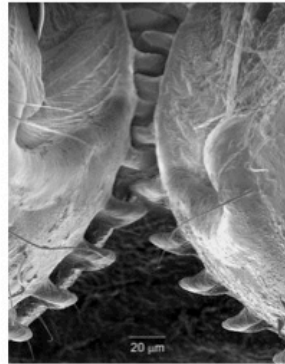
Planthoppers hop with a modified wheel: The Gear.



Planthopper nymph

<http://www.youtube.com/watch?v=cq0Mf2pt2XA>

<http://www.npr.org/2013/09/13/219739500/living-gears-help-this-bug-jump>



Gears on hind legs

Planthoppers synchronize their hind leg movements in 30 millionths of a second using small gears on the first segment of its hind legs (similar to the top of your thigh bone). As one leg prepares to leap, the interlocking gear system causes the other leg to move at the same time. This lets the planthopper to propel itself faster and farther and in a straighter path to escape danger. At such speeds, synchronizing leg movements is very important, as one wrong move could send the insect springing to the side instead of forward.

The Pulley



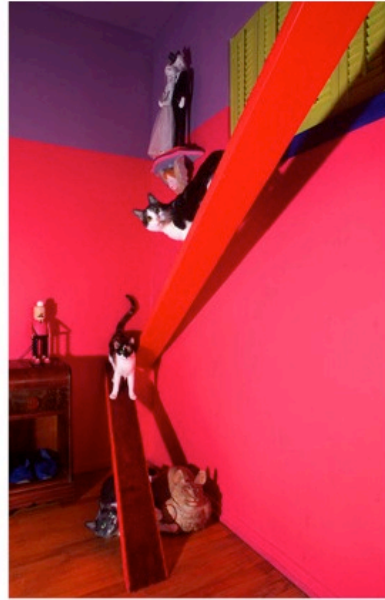
“The pulley is a way of getting force to go around corners...”

“The patella, or knee cap, allows your thigh muscles to lift your lower leg without crushing the knee joint. If the quadriceps were connected directly to your shin, every time it contracted, the bones of the lower leg would grind into the base of the femur, and it would take a lot of effort to move. But by routing the connection over the top of the patella, evolution changed the geometry--when the quad pulls on the lower leg, the force comes from in front of the shin, rather than from directly above, so the shin moves easily.”

The Inclined Plane



Cats like them.



Penguins, too!

<http://www.youtube.com/watch?v=CkMzHGA8GgM>

The Inclined Plane



The Inclined Plane



Ascending flight

85 deg WAIR

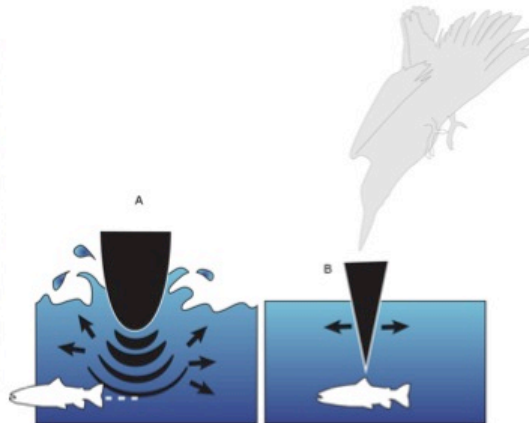
<http://www.youtube.com/watch?v=e81J915TEXg>

J Exp Biol 214:2354-2361, 2011

Wing-assisted incline running (WAIR): when a bird flaps its wings to aid in climbing a slope. Ground birds use this as an escape strategy.

The Wedge

The Kingfisher



“If a kingfisher had a rounded beak, such as on the left, it would push water ahead of it, scaring or displacing the prey. Instead, the wedge-shaped beak and head (right) enters the water without a splash, increasing the chances of a successful hunt. Artist: Emily Harrington. Copyright: All rights reserved.”

<http://www.asknature.org/strategy/4c3d00f23cae38c1d23517b6378859ee>

The Wedge

The Kingfisher fishing!



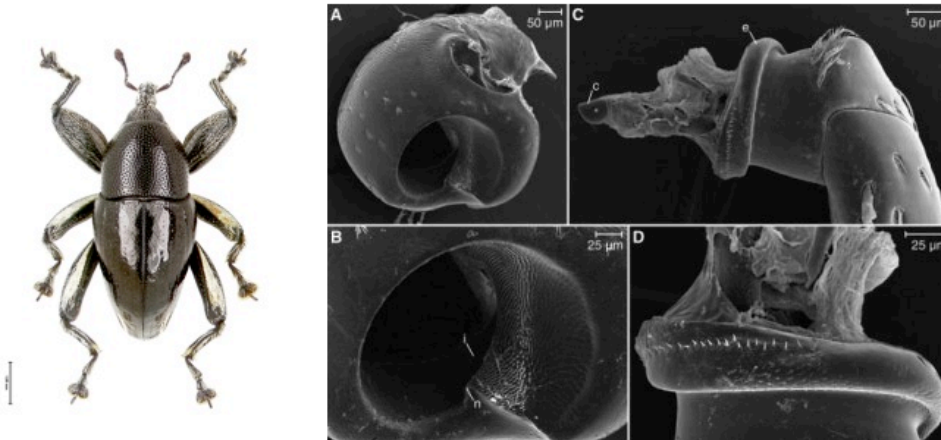
<http://www.youtube.com/watch?v=1CsyenHROSE>

<http://www.youtube.com/watch?v=6YRM0sy3xIY>

<http://besttravelphotos.me/2012/11/14/airborne-fishing-kingfisher-england/>

The Screw

Papuan Weevils have leg joints that screw together!



The nut: The outer part of the joint (the coxa) has an inner screw thread (A & B).
The screw: The inner part of the joint (the trochanter) has an external screw thread (C & D).
The beetles' muscles pull on the leg to turn the screw!

The Screw: Hermit Crabs

As hermit crabs grow, their abdomen grows into a “corkscrew” spiral shape to “screw into the shell” that they are living live in. Most shells contain a right-handed (clockwise) spiral, and most hermit crabs have a “right-handed spiral” for their abdomen. Some species of hermit crabs live in left-handed (counter-clockwise) spiral shells and have a “left-handed spiral” abdomen. As the hermit crab grows, this puts such a hermit crab at a disadvantage in the housing market as left-handed shells are less common.

<http://www.youtube.com/watch?v=tGwoOOz2s2g>

<http://www.youtube.com/watch?v=l8hZ7MM1rOg>



A hermit crab out of it's shell.

http://en.wikipedia.org/wiki/Hermit_crab

Combining Simple Machines: the hamster trap.

<http://www.youtube.com/watch?v=ogCp1W7cRZ4>