Pulleys Used in Hawai‘i

Once 1000s of Hawaiians stood lined up from the mountain to the sea to pass on the heavy stones that made up the fishpond (loko i‘a). A loko i‘a could produce over 2000 lbs. of mullet a year. In 1778, 360 loko i‘a across the Islands supplied the needs of 1000s of people.

When the wood (‘ohi‘a or lama) for the mākahā (sluice gate) was ready, the kāhuna set up the first piece of timber. For this important duty, the wise elder offered a hog and a dog to inspire the increase of fish, and he offered prayers.... The men built the mākahā, binding it together with ‘ie cords. After that they arranged foundation stones around the mākahā grating, and poured in pebbles.

The gates were put between the pond and the ocean. The mākahā were raised and lowered, according to the tide, to trap & harvest the fish that became too fat to go through the gates. The gates were moved by keepers who slept in small guard houses nearby when tides were high so the fish wouldn’t be stolen or killed. They pulled the gates and the ‘ie cords up by hand, like a human pulley system.

By 2003 there were only four fishponds used for aquaculture in the state. Some ponds were destroyed by warring chiefs, but most were destroyed later when traders cut down the trees. This caused dirt to wash away, so they planted mangroves, but these new trees turned the fishponds into mudflats. Now the few remaining loko i‘a in Hawai‘i are being brought back to life by Hawaiians who want to save Hawai‘i’s past and future by fixing them up & protecting the ‘āina.

Science in Hawai‘i: Nā Hana Ma Ka Ahupua‘a – A Culturally Responsive Curriculum Project
Retrieved and adapted 5/3/05 from: www.2qz.com/condo-cruise-ship/20000leagues/20000leagues250.htm;
www.sacred-texts.com/pac/hlov/hlov28.htm; volcano.und.edu/vwdocs/vwlessons/monitors.html;
www.travelwithachallenge.com/Hawaii-Zipline.htm; www.rathburn.net/hol/CostaRica/CR03.html;
www.howstuffworks.com/pulley.htm; www.k12.hi.us/~ttavares/fishpond1.htm; &
http://www.atourhands.com/whaling.html
WHALING & PULLEYS

When foreigners first came to Hawai‘i, whales were hunted for their oil and meat. It took pulleys of great strength with long ropes to hoist whales onto the platform of whaling boats. Without pulleys, whaling could not have been done. The whales could weigh as much as 5,000 kilograms. After almost all the whales became extinct, it became illegal in most countries to hunt most species of whales. However, pulleys are still very important and are used on all ships and in shipyards today.

PULLEYS in VOLCANO STUDY

In 1911 the first successful attempt to measure the temperature of the boiling lava was made scientifically with a pulley. Professor F. G. Perret came from his observatory in Italy to study Kilauea.

They stretched a wire cable 1,500 feet long from wall to wall over Kilauea’s lake of fire. They ran wires through pulleys along this cable and dropped the best instruments they had with them straight down. Some of these were broken before they could read the temperature. The last thermometer registered 1850° Fahrenheit. Later it was again lowered, but, according to Professor Shepherd, "Pele arose in her wrath, grasped the thermometer, flung hot lava on the supporting wires, thereby weakening them, and then with a final jerk broke the thermometer from its supports and swallowed it. Pele seems to like ironware for diet."

Pulleys are used by vulcanologists today to climb down into cooled craters and to drop equipment in to measure volcanic gases, temperatures, the speed flows travel and to take other readings.
Pulleys are also used just for fun on Maui! Now Skyline Eco-Adventures is one tourist attraction located at 4,300 feet on Haleakala Ranch. It opened for business in March, 2003, & is the 1st of its kind in the USA.

Danny Boren, who is from Maui, first saw zipline tours in Costa Rica and thought it would work on Maui without harming the environment. His adventure tour is 1½ hours long and has 4 zipline crossings which are all named for endangered Hawaiian birds. Guides share facts about each species at each stop, so people learn about the nature they are seeing as they speed along the pulley systems on the tour. It is fun and educational.

Skyline guides also let tourists know how safe and strong the equipment is. The harness, made of nylon webbing, can hold 6,000 pounds. It is secured around the legs and waist. It would hold a car up! But you still have to wear a helmet.

Danny says he will donate 10% of profits from Skyline to local nature organizations when his business starts making profits. But he has other ways to give back already – he will offer free zipline tours to volunteers who help ecology groups, like Maui’s Project Malama, Auwahi Forest Restoration, and the Nature Conservancy's Waikamoi rain forest service. Skyline also has a small reforestation area where native koa trees are planted near the company's headquarters.

That's the pono way to earn a living in Hawai‘i and help sustain beauty and nature of Hawai‘i for the future, too!

Science in Hawai‘i: Nā Hana Ma Ka Ahupua’a – A Culturally Responsive Curriculum Project
How Pulleys, Block and Tackle Work

A. Imagine that you have a 100 pound weight hanging from a rope, as shown below on the left. If you want to move the weight up, you have to pull in 100 feet of rope to do it.

B. Now look at the drawing above on the right. If you add a pulley to lift the weight, does anything change?

The only thing that changes is the direction of the force you pull to lift the weight. Instead of lifting up, you are pulling down, which can be easier. You still have to use 100 lbs of force to keep the weight up, and you still have to reel in 100 ft of rope.

But, other pulley systems save you a lot of effort! Read on!
C. When you use two pulleys, the weight is hanging by two ropes. This means the weight is split equally between each rope, so each rope holds only 50 pounds. Now, you only have to apply 50 pounds of force to pull the 100 lb block up (the ceiling “lifts” the other 50 pounds of force on the other end of the rope). This makes your job 2 times easier! Also, if you have more rope, you can pull the weight even higher. This is because…

The more distance you pull a weight, the less force or effort you need to do the job – & the less distance you pull, the more force you need!

D. Pulley systems used in factories, shipyards & mechanic shops now often use two separate pulleys on the same shaft, as shown on the right. So, to hold the weight in the air you only need 25 pounds of force, but to lift the weight 100 feet higher you must now reel in 400 feet of rope. So by cutting the force in half again, you must double the distance you pull again.

TRY IT! Use pulleys in a simple machine project to save energy!
See How Pulleys Work!

Make a model of a mākahā, the kind of sluice gate used in Hawaiian loko i’a, or fishponds. Design a pulley system to make the work easier!

1. Draw a front view of a mākahā here, the way a fish might see it.

2. Think of a good pulley system to raise & lower the mākahā. Carefully draw & label the parts of your system, and explain how much force is needed to lift your mākahā, and how long your rope must be to pull it up.

EXAMPLE:

My 100 lb gate is lifted by pulling down on the left pulley with 25 lbs of force. The middle pulleys are doubles & they pull up & down with 25 lbs more force. The pole on the right also uses 25 lbs of force to hold it all in place. This system uses 400 feet of cord.
TEACHER’S NOTES FOR PULLEYS:

Pages 1-3: Ask students what pulleys can be used for or where they’ve seen them in use. Read page 1, 2 &/or 3 together as a class, or simply describe these examples in a lecture.

Pages 4-5: Read these pages as a group, and if you have the equipment, demonstrate &/or allow student teams to test each type of pulley lifting system with small weights, pulleys & strings.

Any object that rolls can be used as a pulley if you have no equipment, for example, pencils will hold the strings. Known weights are best to use, such as a plastic bottle with 1, ½ or a ¼ liter of water in it. The string can be marked in advance to help students measure distances pulled in centimeters &/or inches.

Force used to pull by hand must be estimated. Encourage students to explore the force-distance relationship described in the hand-out.

Page 6 - Read the instructions and example aloud first, and draw another example on the board, if necessary. Grading criteria suggested is:

1 point – sluice gate & weight shown, front view
1 point – ‘ie cords, pulley(s) shown
1 point - length of cord to pull stated
2 points - force & direction to pull on cords shown
5 points total

Bonus Options:
Students can present their designs to the class & explain how it works. Students can build working models of this design, or design other pulley systems for practical, energy-saving use at school or in the home.