HAWAIIANS LONG AGO truly did their work by hand, but they used some simple tools to help them. They used stone wedges to shape canoes. They also used inclined planes (ramps) to pound poi and to make special gates and channels, called sluices, in the lo‘i patches. In 1821, a Russian sailor wrote:

“This taro fields, excited my attention . . . I saw whole mountains covered with such fields, through which water gradually flowed . . . each sluice formed a small cascade which ran into the next pond, and it was extremely picturesque . . .”

Waipio Valley Lo‘i on the Big Island

This sailor was describing the ‘auwai, or irrigation ditch system, that supplied water from streams to flood taro fields like this one on the Hamakua Coast near Hilo. The Paki ‘Auwai, which he saw, was built to carry water from Luakaha (where Nu‘uanu Pali Drive is today) to taro fields below Wyllie Street in Honolulu. It needed 700 of the chief’s men to build it, but few to work it.

LONG AGO OTHER SCIENTISTS used strategies to solve our problems working with the environment. Archimedes is one Greek scientist and mathematician who invented many simple machines to make work easier for people – even today. He was born in 287 B.C., over 500 years before the first Tahitians came to Hawai‘i. Like the Tahitians, he loved math and was very good at it.

KEY SCIENCE IDEA:

Mechanical Energy
(say: me-KAN-i-cul EN-er-gee)

The energy of a moving object

TYPES OF SIMPLE MACHINES:

* LEVERS
* GEARS
* PULLEYS
* WHEEL & AXLE
* WATER PRESS
* RAMP
* WEDGE
THE ARCHIMEDES SCREW looked like the image on the right. When Archimedes visited Egypt, he invented this device so that fewer slaves would be needed to carry water in buckets from low ground up to where crops were planted. The photo below shows how people today in farms all over the world still use this simple machine.

An Egyptian farmer turning an Archimedes screw by hand to irrigate a field. Helen & Frank Schreider, National Geographic

HOW IT WORKS is like magic! We use human energy to make work feel easier. But really, we are not saving or making any energy. That is impossible! The Law of Conservation of Energy says all we can do is change one form of energy to another. So, we eat to change food energy to human energy. Then we work to change human energy to mechanical energy. We change mechanical energy into whatever we want – machines make heat energy, solar energy, kinetic energy & more!

TODAY SCIENTISTS know that many of the very complex machines we have invented in modern times are harming our planet. Cars parts are mostly simple machines, like water press brakes, wheels and axles, and gears. But put together with gas and oil, cars create pollution that harms the air and water which all plants and animals need to survive. This is why we now look at simple machines as a “new” and better way to use energy to do our work. Mechanical energy is good for us!

SOME COOL IDEAS TO KNOW:

[* Kinetic Energy ... is what moves things, like the energy a ball has after you throw it

[* Potential Energy ... isn’t moving, but it is stored in an object after it has changed its position, like a ball that you place up high & hope it will fall

[* Mechanical Advantage ... is how much work you do using a tool, compared to how much work you have to do if you have no tool, like using a lever to open a tight lid instead of just your fingers.

ALL SIMPLE MACHINES are labor-saving tools. This means that they need less human power to get the job done. This idea has a name – it’s called mechanical advantage.
Machines Then & Now: Bonus Questions

1. What simple machines did ancient Hawaiians use? 

2. Think of examples you know of these simple machines:

- LEVERS
- GEARS
- PULLEYS
- WHEEL & AXLE
- WATER PRESS (also called HYDRAULIC PRESS)
- INCLINED PLANE (also called RAMP)
- WEDGE

3. This toy is called Newton’s Cradle. It was invented by Isaac Newton, a famous scientist, who was trying to find a “perpetual motion” machine - a machine that never stopped and used no energy after it started.

How does the Law of Conservation explain why perpetual motion machines like Newton’s Cradle can never work? 

Science in Hawai‘i: Nā Hana Ma Ka Ahupua’a – A Culturally Responsive Curriculum Project
Adapted and retrieved, in part, 03/05, from: www.hawaiianhistory.org/moments/auwai.html; sss.sd54.bc.ca/hawaii/location.htm; www.mcs.drexel.edu/~crosis/Archimedes/contents.html
4. Why is it good for nature if we use simple machines instead of complex ones?

5. Look at this cartoon drawing by Rube Goldberg.

Passing man (A) slips on banana peel (B) causing him to fall on rake (C). As handle of rake rises it throws horseshoe (D) onto rope (E) which sags, thereby tilting sprinkling can (F). Water (G) saturates mop (H). Pickle terrier (I) thinks it is raining, gets up to run into house and upsets sign (J) throwing it against non-tipping cigar ash receiver (K) which causes it to swing back and forth and swish the mop against window pane, wiping it clean.

Is the drawing above a good example of mechanical advantage?

Why or why not?

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**Teacher’s Resources for Simple Machines & Mechanical Energy**

**Standards & Ideas related to Reading:**

* Humans use strategies to solve our problems working with the environment and technology. (Domain I, Strand/standard 5; Domain II, Strand 1, Standard 2)
* The laws of physics explain the relationship between force, mass, motion of objects and comprehends simple machines, work and power. (II, 4, 15)
* Science, technology and society are all interdependent. (Domain I, Strand/Standard 5; Domain II, Strand 1, Standard 2)
* Science considers the limited resources, impact of pollution, and the fragile environment of Earth in order to make decisions now and for future generations (Domain II, Strand 1, Standard 3)

**Cited Website Sources:**
Retrieved 3/28/05 from [http://www.mcs.drexel.edu/~crorres/Archimedes/contents.html](http://www.mcs.drexel.edu/~crorres/Archimedes/contents.html)

**Quick facts about Archimedes . . .**

- **Born** About 287 BC in Syracuse, Sicily. At the time Syracuse was an independent Greek city-state with a 500-year history.
- **Died** 212 or 211 BC in Syracuse when it was being sacked by a Roman army. He was killed by a Roman soldier who did not know who he was.
- **Education** Probably studied in Alexandria, Egypt, under the followers of Euclid.
- **Family** His father was an astronomer named Phidias and he was probably related to Hieron II, the king of Syracuse. It is not known whether he was married or had any children.
- **Inventions** Many war machines used in the defense of Syracuse, compound pulley systems, planetarium, water screw (possibly), water organ (possibly), burning mirrors (very unlikely).
- **Fields of Science** Hydrostatics, static mechanics, pycnometry (the measurement of the volume or density of an object). He is called the "father of integral calculus."
- **Place in History** Generally regarded as the greatest mathematician and scientist of antiquity and one of the three greatest mathematicians of all time (together with Isaac Newton (English 1643-1727) and Carl Friedrich Gauss (German 1777-1855)).
Hamakua Coast

Waipio Valley [Photo - Overlook] [Photo] [Photo]
Retrieved from http://sss.sd54.bc.ca/hawaii/location.htm
The Waipio Valley is a mile wide lush expanse of overgrown gardens and taro patches. The road down is steep and narrow and can only be navigated by 4WD and wagons. We've only seen the valley from the overlook. 2000ft cliffs surround the valley which is criss-crossed by freshwater streams from the waterfalls that cascade down the valley walls. A gray sand beach forms the mouth of this spectacular valley.


The ‘Auwai of Nu‘uanu Valley

In 1821, Otto von Kotzebue, a Russian naval officer wrote, “The taro fields, excited my attention . . . I have seen whole mountains covered with such fields, through which water gradually flowed; each sluice formed a small cascade which ran . . . into the next pond, and afforded an extremely picturesque prospect.”

Kotzebue was describing the ‘auwai, or irrigation ditch system, that supplied water from streams to flood the taro fields. Wetland taro was the food staple for Hawai‘i. Extensive terraced fields and irrigation ‘auwai were created to grow the staple. Construction of irrigation ‘auwai was a communal undertaking. For example, the Paki ‘auwai, which was constructed to carry water from Luakaha, at the upper reaches of today’s Nu‘uanu Pali Drive, to taro fields below Wyllie Street, utilized a work force of 700 men furnished by the chiefs and other landowners.

Water rights to an ‘auwai were based upon the number of men a landowner furnished to build the ‘auwai. More men resulted in more water rights, which would be applied to irrigate larger parcels of land. Only taro was entitled to water from the ‘auwai. Dryland crops had no claim to ‘auwai water. Use of the water was regulated by time increments, which varied from a few hours each day for a small taro patch to two or three days for a taro plantation. By rotation with others on the ‘auwai, a grower would divert water from the ‘auwai into his taro. The next, in turn, would draw off water for his allotted period of time.

Control of the ‘auwai and its users was directed by the chief holding the most rights to water usage. He was the luna wai, or water boss, who directed the cleaning and repair of the ‘auwai and rewarded or punished growers with increased or lessened rights to water usage according to their performance in tending the ‘auwai.

Today, the historic ‘auwai serve decorative purposes—as landscaped water ways, as small ponds with water lilies, and as display pools for carp. Such a segment of ‘auwai can be seen from the Kimo Drive bridge entering Dowsett Highlands.

By Thomas K. Lalakea