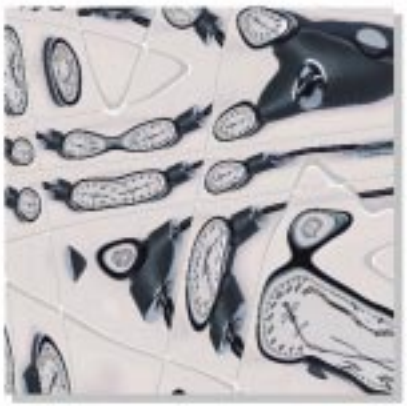


Measurement

Worksheet 9

A worksheet produced by the Native Access to Engineering Programme

What is measurement?

Webster's Dictionary defines measurement as
1. The act or result of measuring;
2. The extent, size, capacity, amount. or quantity ascertained by measuring

Measurement is central to the work of engineers and scientists. It is part of the language they use to communicate with each other and to understand the world. Engineers measure weight, distance, velocity, pressure, force, concentrations and other things. But measuring is also something people do all the time without even thinking about it. We look at our watches or the position of the sun in the sky and measure time. We give directions to someone and measure distance.

What kind of things do we measure?

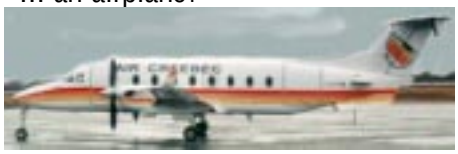
Why is measurement important?

What measurements do you think are critical for...

... a premature baby?

... a chef?

... an airplane?



Source: Aircreebec
http://www.aircreebec.ca

... a winter coat?

Source: Nunavut Tourism
http://www.nunatour.nt.ca/home.html

... a snowmobile?

Source; Ski-doo
http://www.ski-doo.com/english/home.htm

... planting crops?

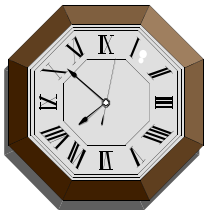
Source: Three Sisters Cookbook
http://oneida-nation.net/food-index.html

... a diabetic?

Source: http://www.obgyn.net/english/pubs/features/tfp/diabetes.htm

Blood sugar, temperature, time, insulation, size, date, volume, pressure, weight, velocity ...

Being able to measure things is sometimes very important to our basic needs of health and safety.



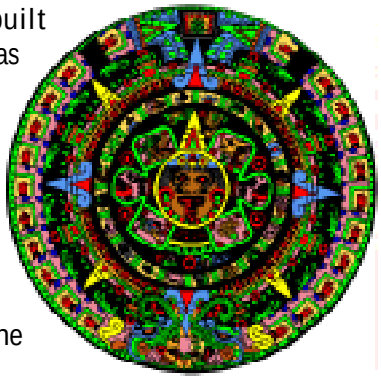
Some ancient history about time

It is hard to know exactly when people began to measure things, but one of the first things we measured was probably time.

Can you think why it would be important to measure time?

Archaeological artifacts such as notched sticks and scored stones, tell us that people have keep track of measurable cycles of time for thousands of years. Ancient peoples probably counted time based on the number of days between full moons or other movements of the stars and planets. Many peoples eventually developed accurate and complex means of measuring and keeping track of time.

About 4000 years ago, ancient people in England built Stonehenge a large stone structure. Part of its purpose was to keep track of seasonal events like the winter and summer solstices (the shortest and longest days of the year). Around the same time the Maya of Central America were also developing means of measuring time. They built large, multi-purpose stone pyramids which were often aligned with the sun so that they indicated the solstices and the time to begin planting or harvesting. The Maya also developed a 365-day calendar which allowed them to track and keep a history of events. The Aztec later incorporated the Mayan year into their calendar stones.



Do you know how the people of your nation measured time?

Telling Time

Eventually, the ability to tell time became more accurate. A number of measuring devices including sundials and water clocks were developed to help tell the time and keep track of hours during the day.

What disadvantages could these methods have had?

Mechanical clocks powered by weights and wound up springs first appeared in the mid-late 1300s: they told the time but weren't very accurate.

What would affect the accuracy of these clocks?

Accurate time telling devices weren't developed until about 200 years later; they were powered by pendulums and even then they could be off by about 10 seconds per day.

Why is accuracy important in measurement?

Atomic clocks are now accurate to within one millionth of a second per year!

Accuracy and Tolerances

Source: http://collections.ic.gc.ca/luxton/sect_3

There are many things which we measure without complete accuracy. Recipes are a good example; if you've ever cooked with your mother, aunt or grandmother, you'll know that they often add a "pinch," "dash" or "handful" rather than measuring out ingredients precisely.

Are there any recipes your family uses which are measured this way?

Even things we think of as accurate, like experiments in a chemistry lab, are only as accurate as the measuring devices used and the experimenter's ability to use them; 30 ml of NaCl solution might actually be 29.5 or 30.5ml. Under certain circumstances accuracy isn't terribly important, but for measuring in science and engineering it is.

What things do you think would have to be measured very accurately?

A motor - whether for cars, airplanes or electric mixers - is made from a lot of smaller pieces which have to work together so that they can drive a machine. In order for a motor to function properly, certain bits need to fit together and others need to fit one inside the other. So, all of these pieces have to be made as close as possible to the size's specified in the motor's design.

What would happen if a piece was too big or too small?

It is nearly impossible to machine mechanical pieces to an exact size, so engineers design pieces to be made within a certain tolerance. Tolerance is how much something can vary from its specified design weight, dimensions, concentration etc. For machined pieces, like those used in engines, tolerances are usually anywhere from ±0.1mm to ±0.25mm.

Coins are minted with very specific tolerances of weight, size and thickness. Can you think why?

Measurement and safety

Healers and medicine people have held and passed down knowledge about medicinal uses of plants and herbs for many generations. Their understanding includes what plants to harvest, when to harvest them, how to prepare them and how much of the preparation to use.

Why would knowing "how much" be important to a healer?

"How much" is a big concern to engineers not just in terms of quantities and sizes but also in terms of safety. Engineers measure the objects and materials they work with for their dimensions. But they also have to know how much the objects and materials can take before they need to be replaced, break, catch on fire, melt etc. In fact, certain engineers spend all of their time testing the things other engineers make to determine just how safe they are. They are called safety engineers.

Source: Underwriter's Laboritories
http://www.ul.com/fire/fire3.html

Safety engineers drop, pull, explode, burn, squish, shoot, run over, prod, poke, erode and otherwise abuse the products which are sent to them for testing.

What kind of things do you think safety engineers test?

Through all their tests, safety engineers take careful measurents so they can ensure the safety of the public and pass what they learn - their knowledge - on to other scientists and engineers. Where healers pass their knowledge of measurements on orally, engineers do it by publishing standards.

Standards

Source: Lego
http://www.lego.com/smallkids/basic.asp

Lego makes much bigger blocks for toddlers.

Standards are publications which specify exactly how certain things are to be made or used in order to ensure public safety. For instance, small toys are choking hazards, especially for babies and toddlers who like to stick things in their mouths. So the American Society for Testing and Materials (ASTM) has developed a standard for toy safety. ASTM F963 says that toy components intended for children under the age of 3 should be oversized and specifies dimensions for toys to big to swallow.

Standards can be mandatory or voluntary. Usually products which meet specified standards carry a label indicating they have been tested for safety.

Many countries have national standards organizations which test, measure and develop standards, like the Canadian Standards Association. There is also the International Standards Organization (ISO) which is responsible for internationally applied standards.)

Another global agency is the International Bureau of Weights and Measures. It actually defines things like how long a second is and how much a kilogram actually weighs!

Why would you want to standardize measurements?

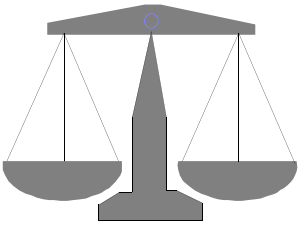
Defining measurements

Measurements used to be defined in a fairly loose way. An inch was originally the width of a man's thumb. A yard was measured as the length of man's belt until King Henry I of England fixed it as the distance from the tip of his nose to the thumb of his outstretched arm.

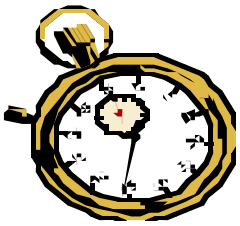
Can you see any problems in defining measurements this way?

Do you know of any traditional measurements used by your nation?

Measurements don't really mean anything unless everyone is using the same standard for measuring.



These days measurements are fairly rigidly defined. A meter is the distance traveled by light in a vacuum during 1/299,792,458 of a second. A kilogram is the mass of an actual piece of platinum housed at the International Bureau of Weights and Measures in France. A second is 9,192,631,770 oscillations of the cesium atom's resonant frequency.



While this kind of precision may seem silly, using standardized measurements is important. It is particularly important to Aboriginal peoples in the negotiation of treaties and land claims. Differences in the definition of distances (like miles or kilometers) could result in a large difference in how much territory is covered by the treaty or claim.

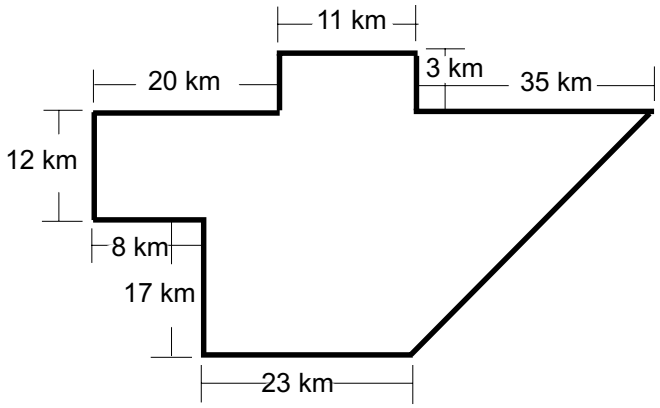
Sources

On-line

1. Astronomy Project
   http://www.schoolnet.ca/aboriginal/science/astronome.html
2. CSA
   http://www.csa-international.org
3. Fighting bank crime with UL-evaluated components
   http://www.ul.com/about/otm/otmv3n2/crime.html
4. Measuring Time
   http://www.worldbook.com/fun/calendars/html/measuring.htm
5. Standard Measurements in Sports
   http://kids.infroplease.lycos.com/ipka/A0770270.html
6. Tolerances
   http://www.designinfo.com
7. Underwriters Laboratories
   http://www.ul.com
8. A Walk through Time
   http://physics.nist.gov/GenInt/Time/boulder.html

Math problems

1. Your nation is renegotiating hunting and fishing territory with the federal and provincial governments. In terms of actual land, your elders say that there was a misunderstanding about the measurements used when the land base was originally calculated more than 100 years ago. While your ancestors used leagues (a distance of about 2.5 miles) to measure distance, those who represented the crown understood that they used miles (1 mile = 1.609 km). The territory in question has the following dimensions.

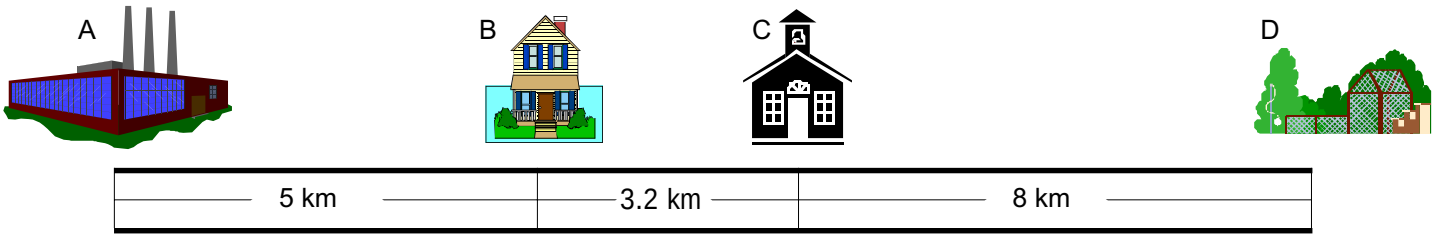


All of the territory boundaries except one run either directly north-south or east-west. Can you calculate…

a. What the territory's dimensions would be (in kilometers) if leagues had been used in the original negotiations?
b. How much land the territory with dimensions from question 1a represents, in square kilometers?
c. How many more times the area your nation is negotiating than what it currently has?

2. You are your community's safety engineer. A plastics manufacturing plant is being built near the community. While the plant will be equipped with the latest safety features and fire control systems, you know that the plastics it makes can be produce toxic smoke in a fire. In order to be prepared for any emergency, you meet with the company's safety engineer. She tells you, that the smoke is dangerous in concentrations 50ppm (parts per million) or above and that their studies show a worst case scenario of 75ppm at the plant. She then tells you the toxicity dissipates at a rate of 2ppm per kilometer and 10 ppm per day.

There are houses (B) 5 km from the plant (A) and a school (C) 3.2 km beyond the houses. If you need to evacuate people from their homes, you would house them in the school gym or in the community centre (D) which is 8 km from the school along the same road.



If there is a really bad fire and the toxicity hits 75ppm at the plant…

a. Would you be able to use the school for evacuees?
b. What would the concentrations be at the houses, school and community centre on day 1?
c. When would it be safe to for people to be in each of these places again?