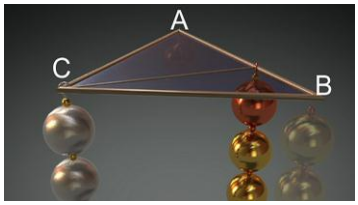

Mathematics, English for Sek I and Sek II

Mathematica - The Principles of Math

13. A balancing Act: Finding the Center of Gravity

10:55 minutes

00:25 Here we have a typical textbook. Now let's try putting it on our fingertip.

00:32 It's hard to make it stay.

00:35 But maybe one of your friends might succeed at keeping it up there.

00:42 Some might try spinning it on the tip of their finger.

00:46 How does that work? How is this possible?

00:50 It can be done if you find a special indivisible point every object has.

00:57 That sweet spot is called the center of gravity.

01:09 For ages, people have used levers to move unwieldy things.

01:19 (caption)
Stonehenge
ancient monument in England consisting of gigantic stones

01:15 That's because it allowed them to move heavy objects with just a little power.

01:26 But it took Archimedes, the great scholar of ancient Greece, to discover the principle behind this phenomenon.

01:31 (caption)
Archimedes of Syracuse (287? BC – 212? BC)
mathematician and physicist of ancient Greece

01:38 Let's imagine two objects on a lever, A and B, each with a different weight.

01:45 Now let's call the distance from fulcrum, the balancing point, to the objects x and y respectively.

01:53 And let's imagine the weight of the lever can be ignored…

01:58 Now if the lever is kept horizontal, then the product of multiplying A and x always equals that of B and y.

02:02 (caption)
lever principle: $A \times x = B \times y$

02:11 That means that when the weight or force of B is larger than that of A, …

02:14 (caption)
when the value of B grows larger

02:18 …or the distance between the fulcrum and B becomes longer, …

02:21 …any object, including the Earth, can be lifted up.

02:23 (caption)
when the value of y grows larger

02:10 Ancient people discovered another principle from use of the lever.

02:39 (caption)
discovery 1
When the lever is parallel and stable, the fulcrum of the lever is the center of gravity.

02:57 Two stuffed bears are keeping this lever parallel.

03:02 Obviously, gravity is at work on both ends, in proportion to their weight.

03:08 But where did this power of gravity go?

03:15 The weight of objects in balance is pulled toward the Earth at the fulcrum as a single unit of force.

03:25 (caption)
The center of gravity is determined when the weight of an object focuses on a single point.

03:25 That means the fulcrum of the lever, working as the center of all that weight, is called the center of gravity.

03:36 (caption)
discovery 2
Every object has a center of gravity.

03:47 Our body weight is composed of gravity pulling on about sixty trillion cells in the body.

03:59 Some are just milligrams of hair…

04:03 …some are gravity pulling on grams of eyes and fingers.

04:11 …and some are the force of a few kilograms from the arms and legs.

04:19 All these parts come together and constitute the entire body.

04:26 As you may understand, each part of the body is independently under the influence of gravity.

04:31 But they are all framed within the body, so they can't move separately.

04:39 Like objects on a lever, these body parts lean or relax in their own place, and balance altogether at the center of gravity.

04:48 That is why we can easily take any object in the world and balance it by finding this sweet spot.

05:01 Now let's see if we can find the center of gravity.

05:05 How about making a mobile for our younger sibling?

05:09 If you want to hang one ball on one end of the light rod and two balls on the other end, at which point do you need to attach the string?

05:22 If you're trying to find the combined center of gravity of two objects, take advantage of the lever principle.

05:23 (caption)
lever principle: $A \times x = B \times y$

05:33 If the weight of one ball is a, then B would weigh 2a.

05:41 If we clean up the calculation…

05:44 Making the distance between x and y a ratio of 2 to 1 will make the rod stay parallel.

05:57 Now how about a triangular mobile made by hanging three balls?

06:04 Since the weight of the three balls pulls at the point where the string was attached, if you can determine the center of gravity between this point and Point C, …

06:14 …then a triangular shaped mobile can also easily be balanced.

06:41 Now this is a frog-shaped plastic plate. We need to find its center of gravity.

06:49 Since the lever principle determined the actual center of weight between two objects, …

06:55 …if you're planning to adapt it to a flat diagram, then you need to calculate the center of weight and distance of every single point. That sounds very complicated, doesn't it?

07:14 But in a case like this, we can use a pin and a thread attached to a pendulum.

07:22 First, attach the plastic plate to the wall with the pin.
Make sure the plastic plate is hanging freely.

07:31 The center of gravity is where gravity is pulling on the object. In a case like this, it is located in the direction that the gravity is pulling.

07:40 If you attach the thread tied to the pendulum, you can clearly see in what direction gravity is pulling. The center of gravity lies somewhere on the line that the thread creates.

07:58 If you repeat the process one more time, you can find a second line created by the thread tied to the pendulum.

08:05 The point where the two threads meet is the center of gravity of the plastic plate.

08:15 This is the most special diagram when it comes to the center of gravity.

08:21 Find the point where the triangle's three median lines meet.

08:34 What is special about a triangle is that the meeting point of the three median lines always indicates the center of gravity determined by the thread tied to a pendulum.

08:58 Do you see that no matter where you create a line with the pendulum, it always passes over the center of gravity?

09:05 Thanks to this characteristic, it's easy to find the center of gravity even with a flat diagram.

09:12 (caption)
triangle's center of gravity = meeting point of three median lines

09:19 There is one more special thing about triangles.

09:23 A triangle's center of gravity always divides the median lines at a ratio of 2 to 1.

09:23 (caption)
a triangle's center of gravity internally divides the median lines at a 2:1 ratio

09:33 It is essential for planes and ships to be well balanced.

09:41 That's why when baggage is loaded and passengers board a ship, if they're not evenly distributed around the center of gravity, their departure cannot be approved.

09:59 When playing golf, the distance the ball travels depends on whether it is hit above or below its center of gravity. That's the deciding factor for success.

10:15 Everything in the world has a center of gravity. By keeping tabs on your own as you take each step, you can become a master of your own.