Friction 3 (Cone angles)

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Have you noticed that volcanic cones have similar angles. This is Taranaki on the North Island of New Zealand.

Image credit: https://commons.wikimedia.org/wiki/File:Mt_Taranaki_(Mt_Egmont).JPG

Taranaki is a *composite volcano* with a cone angle that increases towards the summit. Taranaki is not a huge domed *shield volcano* of low viscosity lava flows like Mauna Loa on the Island of Hawai'i nor a *cinder cone* with straight sides angled at about 30º like many of the fifty or so small volcanoes that dot Auckland city and surrounds.

Cinder cone on Brown's Island close to Auckland city.

Cinder cones are composed of rubble formed as gas-laden magma is spewed out of a volcanic vent and falls back to earth. The cone angle is related to the friction between pieces of rubble and sometimes temporarily increases towards the summit as the cone is being formed. Over time the pile settles into a straight-sided regular cone. That cone angles are not random, and depend on physical properties can be seen on a small scale with a desktop demonstration of sand falling in water.

This circular sand and water filled tank has glass sides separated by 5 mm. When the tank is inverted, over time, heavy black sand descends in narrow streams between air bubbles like sand descending in an egg timer.

The falling sand accumulates in layers with consistent cone angles. The ratio of black sand to fine less-dense white sand is slightly different on the right and the cone angle is slightly shallower. Notice that in this example the angles of the voids above the cones match the cone angles.

To produce interesting cones in the “sandscape” the tank should be allowed to settle for some hours before inverting carefully to create an unbroken line of air bubbles. Delaying inversion increases static friction forces between sand grains, making the sand in the upper half more cohesive, and slows the overall descent.

Three (or more) cones may be formed at the same time.

Three cones have been formed. Notice that again the cone angles are consistent over time and that the cone on the right has a shallower angle. The cone angles of the voids above the remaining upper sand closely match the cone angles below.

These demonstrations show that cone angle is not random but depends on the materials. It is not surprising that all *cinder cone volcanos* have very similar cone angles.

Appendix

These observations raise questions that could be investigated with simple equipment.

For instance:

- a plastic egg-timer could be drilled to allow it to be filled with different types of sand in air or water.

- or large plastic bottles could be connected internally with a smooth narrow neck to make a large version of an egg-timer. The properties of rice and other grains, tiny polystyrene balls and other uniform materials could then be studied.

We might ask:-

1 For glass beads (that can be bought in a range of sizes) is the cone angle independent of radius?

2 Does the cone angle in the lower chamber of an egg timer depend on the density of the sand, given that the sand grains are of the same size and shape?

3 Does the cone angle for sand in the lower chamber of an egg timer filled with a particular type of sand depend on whether the sand is dry or wet (when the egg timer is filled with water)?

4 Can materials be found with remarkably high and/or low cone angles when dry and/or when in water or another liquid?

5* Could materials be found with the same shape, size and density, but different surface roughness (coefficients of friction)? If such materials can be sourced how does the cone angle depend on the coefficients of friction?

6* Could materials be found with the same shape, size, and surface roughness (coefficients of friction) but different densities? If such materials can be sourced how does the cone angle depend on density?