Energy/heat and temperature

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When I set up my *Flat ball challenge* I made four balls of the same size. We could not both do it twice with the same ball because flattening the ball on the ground and remaking it warms it slightly and makes it easier to flatten a second time.

Two questions can be asked.

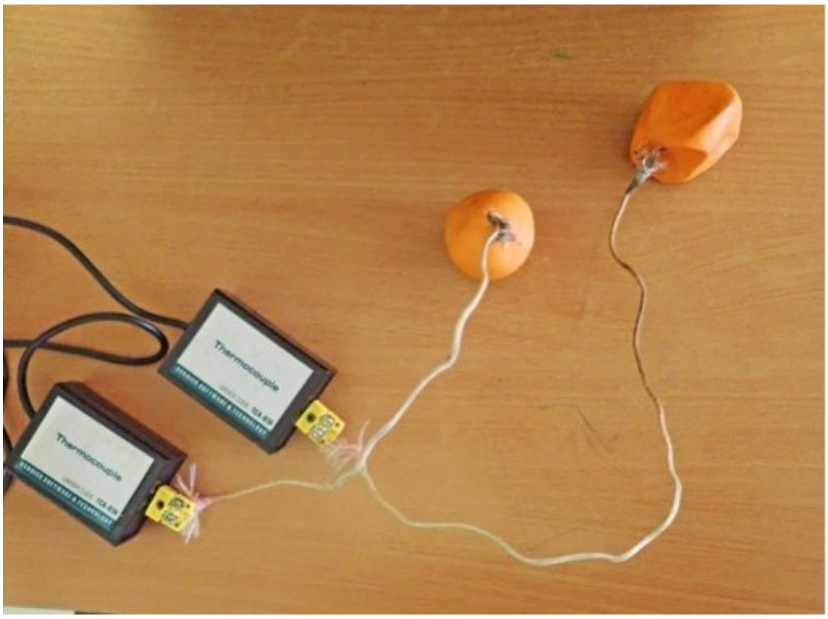
How much does the temperature rise after one throw?

… and …

Does throwing the ball harder raise the temperature more?

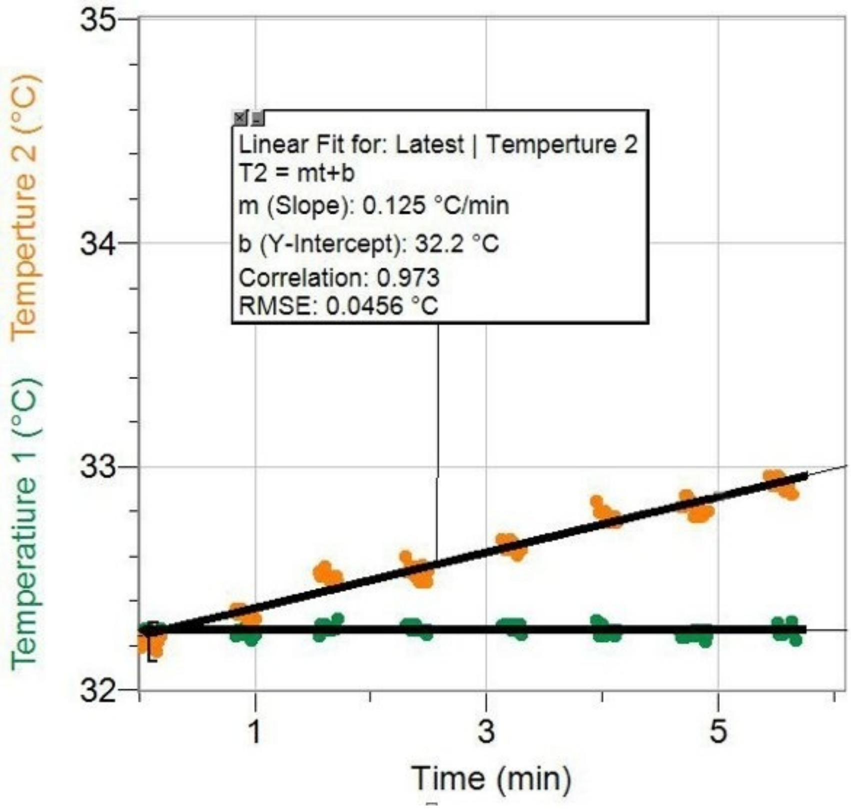
Part 1

To find answers to these questions we used two clay balls with thermocouples connected to a computer. One ball was dropped repeatedly from 2 metres and the other was left on the table.



The temperature measuring thermocouples are from Vernier. Many schools have them, or similar equipment from other companies. Ask them.

The ball was dropped, reformed a little and dropped again, ten times from 2.0 metres as quickly as possible. The results are graphed below using the Vernier program Logger Pro. The points in green show that the temperature of the ball on the table remained constant.

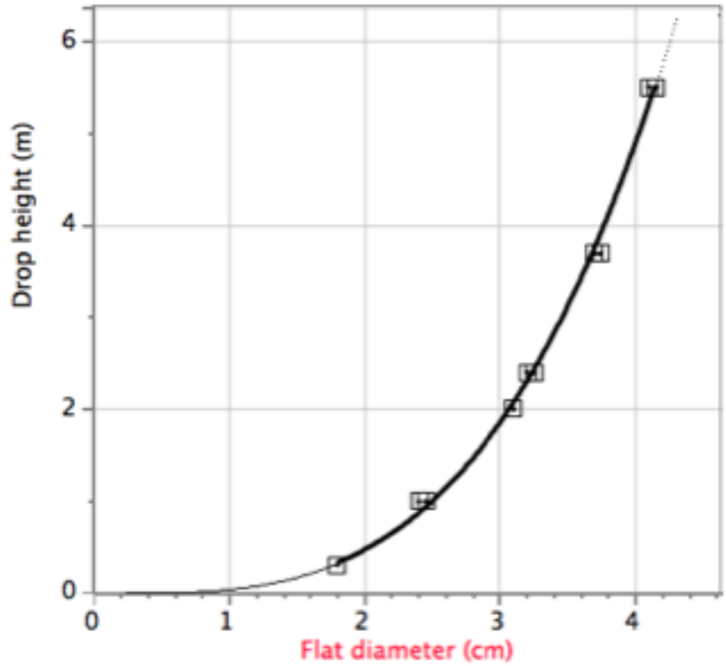


After each set of ten drops the temperature of the deformed clay rose by a small amount. The small scatter of points shows the accuracy of the temperature measurements. The orange data plot is a straight line with a slope of 0.125 ºC/min. Ten drops raised the temperature by the same amount each time.

Part 2

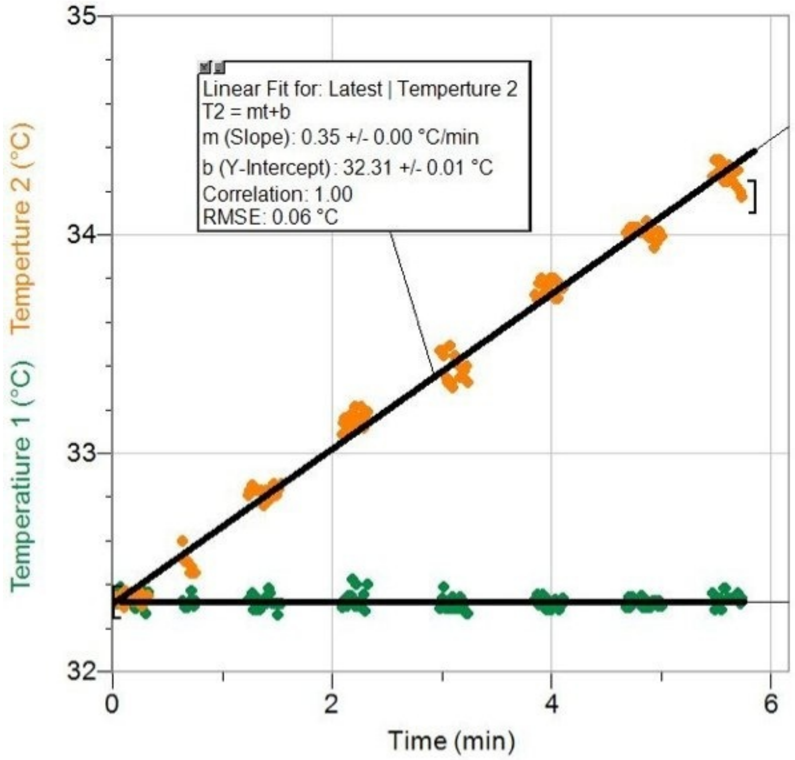
To answer the second question we would like to drop the ball from much higher so it hits the floor faster. That's not possible to do by dropping the ball, picking it up, reforming it quickly and dropping it again because my arms are not long enough. I could throw the ball but I can't drop it.
To solve this problem the ball was dropped from a range of heights and the diameter of the flat bottom was measured each time.

Drop height versus flat circle diameter



I sat in a chair and hurled the ball at the floor. The diameter of the flat bottom when I threw the ball (4.3 cm) was the same as it would have been if I'd dropped it from a height of 6 metres.

Throwing the ball and repeating the measurements gave a steeper straight line graph, because the temperature rose more after each ten throws.



Effectively dropping the ball from three times the height (6 m) increased the temperature rise by about three times.

Potential energy (a new word)

To make sense of this scientists invented new words and a new way of taking about what they came to call *energy*. To understand what they did we need to learn their new words and what they mean.

When we pull something heavy into the sky, lift it against its weight, it is said to gain *potential energy* (PE).

PE (in Joules) = 10 x (mass in kg) x (height in metres)

If we lift one kilogram one meter, the gain
in potential energy is defined as 10 Joules.

That is a *definition*. We can't argue about that: just learn it.

Potential energy

Potential energy can be dangerous. For instance: would you sit and eat your lunch on a rug under a 50 metre coconut tree? *I wouldn't*. A coconut on the head from 50 metres would put me in hospital.

The potential energy of a 2 kg coconut 50 metres up a tree is defined as 10x2x50 joules. *We will worry about why the 10 is in there later.*

$$10 \times 2 \times 50 = 1000 \text{ J}$$

Any small rise in temperature is not a problem, but if that falling coconut hits my head those 1000 joules of energy will do some damage.

We have found that the temperature rise of a clay ball on impact is proportional to the *potential energy* given to the ball by lifting it.
If you have a little trouble understanding exactly why, don't get upset. Until about 1850 not even the best scientists said that. They thought temperature rise was due to a fluid called *Caloric* that got beaten out of things. They thought that a temperature rise when a clay ball hits the floor is due to a little bit of Caloric that escapes from the ball and the floor. *That is silly* … but that was taught in schools and universities everywhere.

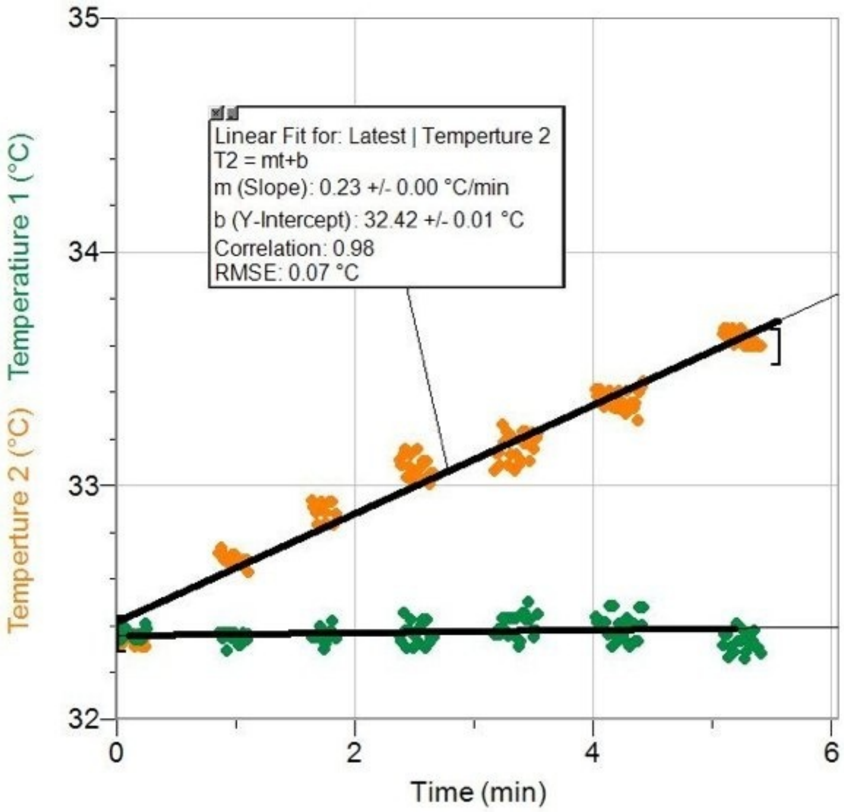
An Englishman called James Joule ended the Caloric story around 1850. Joule experimented at home for years with paddles driven by falling weights that stirred water. He finally came to understand that the size of his weights and the distance they fell determined the temperature rise of the water. He understood that there was no such thing as *Caloric*.

Part 3

When clay hits the floor it gets warmer, but what about the floor. Does some of the energy warm the floor?

The ball was now thrown at a clay pad that deformed as the ball hit it.

The ball was thrown ten times in sets as before.



This time the ball temperature rise was less on the clay pad than when it had hit the floor.

Less of ball energy has now gone into heating the ball and a large percentage has deformed and heated the clay pad.

That raises more questions.

> *How much potential energy (how many Joules) are needed to raise the temperature of one kilogram of clay by one degree celsius.*
>
> *… and …*
>
> *If we know that, could one kilogram of water be raised by one degree with the same amount of energy or would we need more?*

How could you find answers to these questions? Could you do that yourself without asking “google”. Science is like that - a good question answered leads to more questions.