Mysterious eggs

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Why is the result of the "egg race" so surprising? Why do we expect the hard-boiled egg to be the winner? Everyone knows how to distinguish the hard-boiled egg from the raw one... – this is the reason why our intuition fails in the prediction of the race result. Our experience tells us that it is easy to make the hard-boiled egg spin and once set in motion it is turning for a long time. On the contrary, the raw egg does not turn easily and stops quickly. We tend to attribute to the hard-boiled egg a property which can be described as "easiness of turning" and we expect it to roll down faster than the raw egg deprived of this quality. However, the result of the race forces us to verify this expectation.

Let us first consider why does the hard-boiled egg spin so easily while the raw one doesn't. The difference is that in the first case the eggshell is strongly tied together with the inner parts and by setting the egg in motion we make the whole mass spin. In the case of the raw egg – we basicly turn only the eggshell while the inner parts remain almost immobile. The work involved in the case of turning the hard-boiled egg is much greater than in the case of the raw one and, in consequence, the energy of the rotational motion is much greater than the one acquired by the raw egg. However, if we turned the raw egg long enough we could make it spin just as well as the hard-boiled one.

The situation looks different when the eggs are rolling down the slope due to gravity. The gravitational force acts on the whole egg and the speed is determined by several factors. At the top of the inclined plane both eggs have the same potential energy. When they roll down it changes into kinetic energy of motion in a straight line and rotational motion. At the bottom of the slope (and at each point of the inclined plane) the sum of both types of kinetic energy must be the same for each egg. The inner part of the raw egg is not turning with the same angular velocity as the eggshell so its rotational kinetic energy is smaller than that of the hard-boiled egg. In consequence, the kinetic energy of motion in the straight line is greater for the raw egg and this is why it wins the race!

Using the conservation of energy principle and assuming that eggs of mass m and radius r roll down the plane of length l inclined at the angle α, one can easily obtain the formula for the time needed to roll down the plane:

$$t = \sqrt{\frac{2l}{g \sin\alpha}\left(\frac{I}{mr^2}+1\right)}$$

where I stands for the moment of inertia of the egg.

This equation yields that the smaller the moment of inertia of the object, the shortest the time t to cover the distance l.

By the way, there is a very important reason for the yolk of the egg not to take part in the rotational motion. In the upper part of the yolk the germinal disc is situated which remains always on top, closest to the source of heat – the body of the lying hen. It enables proper temperature to be maintained which is essential for the developing new life.

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