Journal of Physics Special Topics
An undergraduate physics journal

P5_4 Earth's Oven

S. Sanjeevvijay, L. Munt, G. Iordanidis

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

December 5, 2024

Abstract

In this paper, we determine the initial velocity that a whole chicken refrigerated to 5 °C would require if it were dropped through the Earth as an unconventional cooking method. When dropped with zero initial velocity the chicken reaches 821 °C, causing it to burn. To prevent overcooking, the chicken is found to need an initial velocity of 50 km s^{-1} raising the internal temperature of the chicken to 91 °C, an ideal temperature for cooking.

Introduction

The Earth is composed of several layers, each with its own temperature profile. These layers include; the crust, mantle and core. Figure 1 shows how the temperature of the Earth changes with depth.

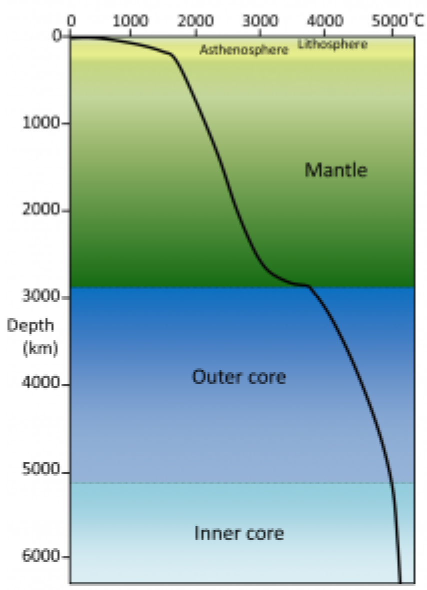

Figure 1: Graph of temperature as a function of depth below the Earth's surface [1].

The crust is the outermost layer and is relatively thin and cool. Temperatures in the crust increase with depth, reaching around 1000 °C at the boundary with the mantle. The mantle is the thickest layer, composed of hot, solid rock, with temperatures ranging from about 1000 °C at the top to around 3500 °C at the core-mantle boundary. The core, the Earth's innermost layer, is divided into a solid inner core and a liquid outer core. Temperatures in the core are extremely high, reaching around 5500 °C in the outer core and up to 6000 °C in the inner core.

The research in this paper explores the novel technique of cooking a chicken by dropping it through the Earth. Several assumptions are required for this; the chicken does not burn up, there is no air resistance (vacuum), gravity is of constant magnitude throughout and the heat energy is distributed uniformly across the chicken, heating it evenly.

Method

Initially, the chicken is modelled as being dropped from one side of the Earth under free-fall with no initial velocity considered. Given the listed assumptions, this chicken will appear on the other side of the Earth approximately 38 minutes later. To calculate the energy transferred to the chicken, Newton's law of cooling is considered [2]:

$$\frac{dT}{dt} = -k(T - T_0) \tag{1}$$

where dT is the change in temperature, dt is the change in time, T is the temperature of the object (refrigerated chicken, 5 °C), T_0 is the temperature of the surroundings and k is a constant equal to 0.0073 min^{-1} [2].

Using the data from figure 1, the model for distance at a time can be combined with equation 1, whereby it is rearranged for dT. This temperature change can be integrated across the data points for depth and their associated change in time to find the temperature of the chicken as it progresses through the Earth.

Figure 2 displays this temperature as a function of depth, with a line showing the comparison to the required temperature to kill bacteria [3].

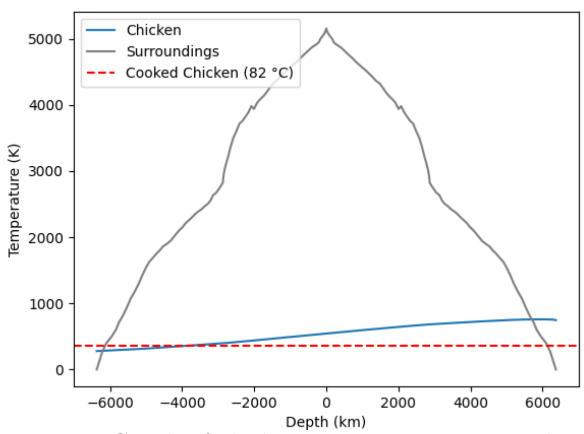

Figure 2: Graph of chicken temperature against depth, initial velocity 0 m s^{-1}.

This result shows that the chicken would be cooked long before it exits to the other side of the Earth. To minimise overcooking, the chicken can be dropped with an initial velocity. Figure 3 shows the temperature of the chicken over time when dropped with an initial velocity of 50 km s^{-1}.

For a chicken to be safely cooked it must reach an internal temperature of 82 °C [3], and the

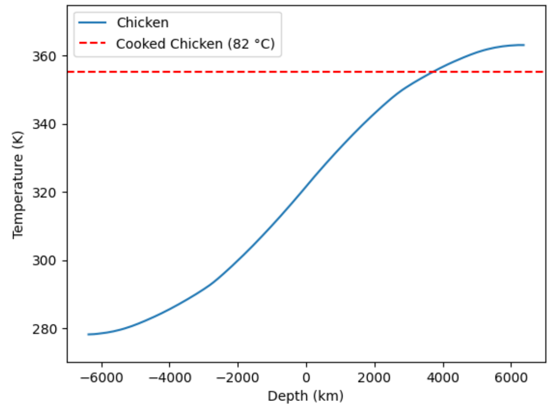

Figure 3: Graph of chicken temperature against depth, initial velocity 50 km s^{-1}.

final temperature of the chicken with an initial velocity of 50 km s^{-1} is 91 °C following its 251 second free-fall through the Earth.

Conclusion

The models generated within this report show that to safely cook a chicken, with the assumptions cooking a chicken dropped through the Earth is uniform, the magnitude of gravity is constant and there is no air resistance, the chicken would need to be dropped at an initial velocity of 50 km s^{-1}, reaching a final temperature of 91 °C. In the case where gravity varies with depth, the transit time would increase, requiring an increase to the initial velocity slightly greater than this increase in time.

References

[1] Steven Earle. *9.2 The Temperature of Earth's Interior*. Opentextbc.ca, Sept. 2015. URL: `https://opentextbc.ca/geology/chapter/9-2-the-temperature-of-earths-interior/`.

[2] *Newton's law of cooking chicken — nephrophysiologist.blogspot.com*. `https://nephrophysiologist.blogspot.com/2013/07/newtons-law-of-cooking-chicken.html`. [Accessed 20-11-2024].

[3] *Chicken Cooking Times*. Chicken.ca. URL: `https://www.chicken.ca/chicken-school/chicken-cooking-times/`.