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A2_5 Physics of Ice Age

A. Hennessy, S. Manivannan, G. Page, L. Suller

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

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Abstract

This paper looks at how much force is required in order for Scrat from Ice Age to form a crack through the ice sheet. This was calculated to be 6.25×10^6 N. As an acorn would not be able to withstand such force, we then went on to calculate the tensile stress in order to determine what material could.

Introduction

Ice Age is a treasured family movie that is loved by many. Throughout this paper we will explore the physics behind the iconic scene of Scrat - the squirrel - accidentally creating a crack through the ice sheet. We started by looking at the force that is required in order to break an ice sheet which comes from the relationship between flexural strength. This is the resistance of a material against deformation and the bearing strength. The bearing strength is the maximum stress load that an object can obtain before it collapses [1].

We then also looked at the tensile stress, which is the magnitude of the force divided by the cross sectional area [2]. In other words, it is the maximum stress that it can withstand before breaking at this force. We then compared it to the tensile strengths of different materials in order to see if there was such a material that would not shatter before forming the crack due to the vast amount of force applied.

Method

In order to start the problem, we looked at how we would calculate the force F required to break the ice. This was done by using the formula,

$$F = CFh^2, \quad (1)$$

where C is the constant of proportionality between flexural strength F and bearing strength. h is the thickness of the ice sheet [3].

CF can be taken as 1, in the case of ice according to calculations which can be represented as the constant A. This then simplifies Gold's Formula

$$F = Ah^2. \quad (2)$$

Using the calculated force, we then found the work done W by means of the equation,

$$W = Fd, \quad (3)$$

where d is the height of the squirrel assuming he drops it from the top of his head, taking this value to be 2.44 m [4]. This then enables us to calculate the speed v at which Scrat would have to throw the acorn by rearranging the formula for kinetic energy W_{KE},

$$W_{KE} = \frac{mv^2}{2}, \quad (4)$$

Figure 1: Fact card on Scrat, where the height of Scrat was found [4].

where m is the average mass of an acorn, which we found to be 3.17×10^{-3} kg. In this method we assume the kinetic energy of the acorn is equal to the work done by Scrat lifting it above his head.

The final part of the problem was to calculate the tensile stress σ in order to determine if there could be a material that could withstand the force applied. To do so we used the equation

$$\sigma = \frac{F}{A}, \tag{5}$$

where A is the cross sectional area of the acorn, with an average radius of 1.2×10^{-2} m.

Results

After performing our calculations, we found the force required to crack the ice to be 6.25×10^{6} N. We then used this value to calculate the work done by the force which came to be 1.53×10^{7} J. By using the energy calculated, we went on to find the speed at which the acorn had to be thrown in order to achieve such a force , which came to the value of 98089 ms^{-1}.

The force calculated was then used to work out the tensile strength of a material needed, which was 1.38×10^{10} Nm^{-2}. No material on Earth has the tensile strength required.

Assumptions

We made our calculations by assuming the fact that Ice Age took place in the arctic, and used the average thickness of the Ice sheets from Greenland which is between $0.8 - 4$ m . In addition, we also took such a absurd height for Scrat as stated on the Ice Age fandom page [4].

Conclusion

To conclude, we found the speed at which Scrat had to throw the acorn in order to form a crack in the ice sheet to be 98089 ms^{-1}. The tensile strength at the force needed to break the ice sheet which came to be 1.38×10^{10} Nm^{-2}. No material on Earth has a strength this high. With the material of highest tensile strength on Earth being tungsten, 2.9×10^{8} Pa [5].

References

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