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A3_7 Density of an Elf

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Abstract

In the film and book 'The Fellowship of the Ring,' the elf Legolas is shown to walk on the surface of a snow bank. This paper outlines the investigation into the density the character, as portrayed by Orlando Bloom, would have to be in order for this to be a possibility. It was found that his mass would be 6.05×10^{-5} kg, giving him a density of 7.75×10^{-4} kgm^{-3}.

Introduction

In the popular book and movie franchise 'The Lord of the Rings,' there is a race of people called the elves, one of which being the character Legolas, who shows the ability to walk on the surface of snow. This is shown in the film 'The Fellowship of the Ring,' where Legolas walks high above his mortal companions who toil through the snow. In order to achieve this, he must have had an extraordinarily low mass, and thus very low density. We calculated the mass and density he must have had.

Theory

To find the net force of Legolas on the snow, we used the equation for the Young's modulus (Equation 1).

$$E = \frac{\frac{F}{A}}{\frac{\Delta L}{L}}. \tag{1}$$

Here, E is the Young's modulus, ΔL is the change in length of the material (i.e. the change in depth of the snow), L is the depth of the snow, F is the force applied to the snow, and A is the area over which the force is applied. A value for the Young's modulus was found to be 31.6 MPa [1] by using the density of settled snow to be 250 kgm^{-3} [2] and comparing with the graph found in [1]. As no obvious imprint can be seen in the scene in the movie, an assumed indentation of 1 mm was used for the compression distance. From observation of the scene, one of the other characters, Aragorn, is seen to be up to his waist in the snow. By using the height of the actor, Viggo Mortensen, of 1.8 m [3] the depth of the snow was calculated to be 0.9 m. To work out the force applied to the snow, we took the area to be when the pressure was its highest, which is when only one foot was taking all the weight from Legolas' body. The actor Orlando Bloom has an approximated size 8 shoe [4] give an approximate foot area of 0.0169 m^2 [5]. This area was then used to calculate the force applied to the snow. By taking away the buoyancy force of Legolas(Equation 2) from the net downward force, it was possible to calculate Legolas' weight. In this equation, F_B is the buoyancy force, V is the volume of displaced fluid (the volume of Legolas), and g is the acceleration due to gravity. To find this, the value for acceleration due to gravity on Middle Earth, the continent where the story takes place, was assumed to be the same as on Earth, being

9.81 ms^{-2}.

$$F_B = \rho g V \qquad (2)$$

Legolas' volume would be the volume of Orlando Bloom. This was given by the mass of the actor (77 kg [4]) divided by the average density of a human (985 kgm^{-1} [6]). The mass of Legolas could be found using Equation 3, where the symbols have their usual meanings.

$$F = mg \qquad (3)$$

By taking the mass of Legolas and dividing it by the volume of Orlando Bloom, we found the density of Legolas.

Results and discussion

The net force on the snow applied by Legolas on a single foot was calculated to be 5.94×10^{-4} N. The volume of Orlando Bloom was calculated to be 0.0781 m^3, giving a buoyant force of 9.57 mN. This gave a weight of Legolas to be 9.63 mN, and a mass of 9.82 mg. This would mean that Legolas had a density of 0.982 gm^{-3}.

Conclusion

The density of Legolas was found to be extremely low, as would be expected from someone who can work on snow while others trudge through it. This low density would indicate that the physiology of elves is vastly different to that of humans, and it is unclear what this would be. At such a low mass, Legolas would also be susceptible to changes in air pressure and, in denser fluids, perhaps even at altitudes with high air pressure, Legolas would appear to be even lighter. Consistency across the films could explored in further research, to see whether this density is accurate with Legolas' interaction with other surfaces such as grass.

References

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