View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by University of Leicester Open Journals

Journal of Physics Special Topics

A2_5 Rolling Violet

I. Griffiths, G. Douglas, T.O. Hands, D.A. Marshall

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

November 21, 2011

Abstract
In the film *Charlie and the Chocolate Factory*, the character Violet Beauregarde swells up and becomes a very oversized blueberry after chewing a non-perfected strip of chewing gum. She is then rolled out of the room by three Oompa-Loompas and through the door with the assistance of her mother. This paper investigates what force would be required to start Violet rolling and finds that it is likely to require four times the amount of Oompa-Loompas shown in the film.

Introduction

In the 2005 adaptation of *Charlie and the Chocolate Factory* (directed by Tim Burton), Violet Beauregarde is shown to swell up to a very large size, that is much greater than is shown in the 1971 version of the film. This size is shown to be moved very easily by the Oompa-Loompas.

Moment of inertia

As Violet is rolled out of the room, it is obvious to consider what force would be required to start her rolling. Therefore, we consider her moment of inertia. The structure of Violet is not described in depth in the film, but it is likely to be quite complex. As a simplification we consider her to be of constant density, such that she can be modelled as a solid sphere, which has the moment of inertia of,

$$I = \frac{2}{5}mr^2, \tag{1}$$

where m is the mass of the sphere and r is its radius [1]. If we consider the torques around the centre of mass, then we can equate the force required to the moment of inertia, as,

$$\tau = I\alpha, \tag{2}$$
$$= Fl, \tag{3}$$

where α is the angular acceleration, F is the force required to create the torque, τ, at a distance of l away from the axis of rotation (which will be the centre of mass) [1]. Using equations 2 and 3, the force required will be,

$$F = \frac{I\alpha}{l}. \tag{4}$$

Combining equations 1 and 4, gives,

$$F = \frac{2}{5}\frac{mr^2\alpha}{l}. \tag{5}$$

As we do not know the mass of Violet, it is more logical to use a density and a volume, so using $m = \rho V$ and $V = \frac{4}{3}\pi r^3$, equation 5 becomes,

$$F = \frac{8}{15}\frac{\pi\alpha\rho r^5}{l}. \tag{6}$$

The Oompa-Loompas push Violet in two different ways, the first is via walking backwards on top of her, the second is by pushing her from the ground. Both of these forces are applied tangentially to Violet, therefore l is equal to the radius, this reduces equation 6 to,

$$F = \frac{8}{15}\pi\alpha\rho r^4. \tag{7}$$

Film relations

The force required is a function of α, ρ and r, none of which we have exact values for. However, we can, with the exception of Violet's density, infer them from the film. Violet, when rolled, rotates approximately once every 10 seconds at what appears to be a constant velocity, with the initial push being approximately a second long, therefore the initial angular acceleration is 0.1 rev/s^2, which is 0.6283 rad/s^2. The height of

Fig. 1: A still from the film used to generate approximate sizes for Violet and the Oompa-Loompas [3].

Violet and the Oompa-Loompas can be approximated using the height of the actress who plays her mother (Missi Pyle), who is 1.80 m tall [2], and the still from the film shown in figure 1[1]. This gives the height of Violet as 3.15 m (and therefore a radius of 1.58 m) and the height of the Oompa-Loompas as 0.73 m.

Force required

Using the average density of a blueberry as 630 kg/m^3 [4], equation 7 gives the force required as 4133 N. The maximal pushing force varies on the distance away the object is and varies from 583 N to 1285 N for an average adult male at shoulder height pushing with both hands [5]. The average force for all the distances is 857 N. Using this average, it would require 5 adult males to start Violet rolling. The average adult male height is 1.68 m [6], so an Oompa-Loompa at 0.73 m is approximately 43% of the average adult male. If we assume that an Oompa-Loompa, therefore, can push with a force that is 43% of an adult male, it would require 12 Oompa-Loompas to start Violet rolling. Alternatively, the Oompa-Loompas could have an incredible strength. For 3 Oompa-Loompas to be able to push Violet, would require them to be able to push a force of approximately 1400 N, however they are shown to be able to push Violet easily which would imply a much greater maximal pushing force.

Conclusion

It is highly likely that the strength of an Oompa-Loompa is proportional to that of a human, considering that Violet's mother assists the Oompa-Loompas and is shown to do so with the same ease as they do. Therefore, the film shows an insufficient amount of Oompa-Loompas being able to push Violet.

References

[1] P. A. Tipler and G. Mosca, *Physics for Scientists and Engineers*, 6th ed. (W.H. Freeman and Company, New York, 2008)

[2] `http://www.imdb.com/name/nm0701512/` (retrieved: 15/11/2011)

[3] Burton. T (Director), *Charlie and the Chocolate Factory* (2005) [DVD] (Warner Home Video)

[4] Wolfram|Alpha Knowledgebase, 2011. `http://www.wolframalpha.com/input/?i=blueberry+density` (retrieved: 15/11/2011)

[5] `http://msis.jsc.nasa.gov/sections/section04.htm#Figure4.9.3-6` (retrieved: 15/11/2011)

[6] Wolfram|Alpha Knowledgebase, 2011. `http://www.wolframalpha.com/input/?i=average+male+height` (retrieved: 15/11/2011)

[1] This particular still was chosen as Violet is shown to only just get through the door and it has the least amount of distance between Violet and her mother, which reduces errors in the approximation.