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A3_1 "Scared Potter?": The Force of Spells

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Abstract

In this paper we investigate the magnitude of the force experienced by a body following an impact from a spell in the Harry Potter film series. After comparing five different spells we determined that the strongest spell was cast by the character Dobby, producing a force of 3600 N. Comparing this to the force of a static push, we find that this force is not large enough to propel a human several meters in the real world.

Introduction

In the magical Harry Potter films when a spell is cast against an opponent they are sometimes thrown backwards, as seen during the duelling club scene in the second film 'The Chamber of Secrets'. We will be looking at the impact of five different spells on their targets and the force exerted on the body to determine which spell is the strongest.

Theory

For each of the spells we assumed that the targets followed a parabolic trajectory. From each scene we accurately measured the time that each of the targets were airborne by playing the clip at a quarter of the speed and using a stopwatch before scaling the time up to full speed. As the y value is zero at the beginning and end of the flight, we set equation (1) to zero and then rearranged it for equation (2) to find v_{0y}, where y is the vertical motion, v_{0y} is the vertical component of velocity, t is the time of flight (ToF), and g is the vertical acceleration.

$$y = v_{0y}t - \frac{1}{2}gt^2 \quad (1) \qquad v_{0y} = \frac{1}{2}gt \quad (2)$$

From v_{0y} we were able to determine the initial velocity, v_0, by using equation (3), assuming that the angle the body makes with the horizontal, θ, is 45°.

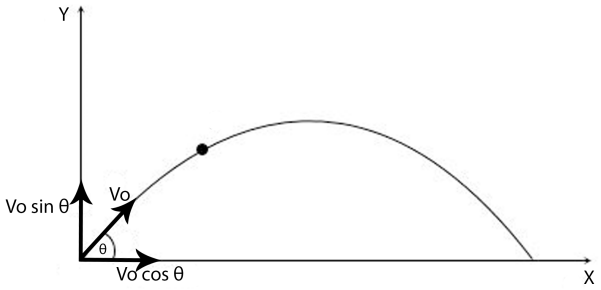

Figure 1: Assumed projectile motion of target

$$v_{0y} = v_0 sin\theta \quad (3)$$

We then determined the acceleration, a, and subsequently the force, F, using equations (4) and (5). To do this we said that the body accelerated up to v_0 in 0.25 s. This value was found from measuring the time between the spell visibly impacting the body and the body leaving the ground. We assumed that all spells acted over the same time period due to lack of clarity in some scenes.

$$a = \frac{\Delta v}{\Delta t} \quad (4) \qquad F = ma \quad (5)$$

For the mass, m, of the characters, in scenes 1,3,4 & 5 (see appendix) we used the average mass of an adult male, which we took to be 70 kg. In

scene 2 we used the mass of an average 12 year old boy [1] which we found to be 40 kg.

Results

The values of force calculated are shown in Table 1 along with the ToF and velocity for each spell. These values are then compared in Figure 2.

Spell	t [s]	$v_0 [ms^{-1}]$	m [kg]	F [N]
Avada Kedavra	1.1	7.6	70	2100
Expelliarmus	1.7	8.4	70	3300
Stupefy	1.8	12.4	70	3500
Everte Statum	2.3	16.0	40	2600
Dobby's Magic Hands	1.9	13.0	70	3600

Table 1: Values used in calculations for each spell

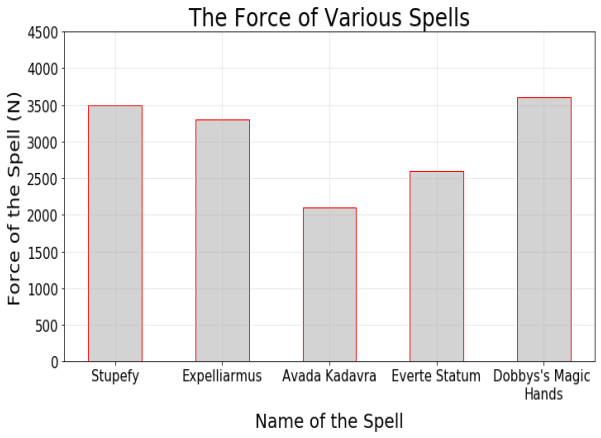

Figure 2: Forces associated with each spell

Discussion

From Figure 2 we found that the spell Dobby casts is the strongest out of the five spells, producing a force of 3600 N. We expected 'Stupefy' to exert a force considerably greater than the other spells due to the fact that the purpose of the spell is to launch the recipient backwards, however it only produced 3500 N which makes it the second strongest.

Curiously, the smallest force was produced by 'Avada Kedavra', which is known as the 'killing curse', commonly referred to as the most powerful spell in the Harry Potter universe.

By comparing these forces to the force exerted by a static push, which we found to be approximately 1000 N [2], it is clear that the forces we calculated would not be enough to launch a human several meters. We believe the main reason these forces are so small is due to the fact that these ToF measurements are taken from films where the actors are propelled using wires and other practical effects, as well as cutting to different camera angles. This makes the duration of the flight appear longer as the falls are no longer natural. These factors result in unrealistic ToF measurements. Another possible factor contributing to the inaccuracy of these measurements is human error when measuring these times, however this impact would be small.

Conclusion

We found that the spell which exerted the greatest force was cast by Dobby, producing 3600 N, and the weakest spell was 'Avada Kadavra' with a force of 2100 N. These results are clearly unrealistic when compared to a push. However, there is a large degree of difficulty when applying real world physics to these spells due to the magical and cinematic aspects of this universe. This explains the differences between the calculated and expected results.

Appendix

The scenes referenced in this article are shown below as follows: Spell, Target, Film, Scene.
Scene 1: Expelliarmus, Gilderoy Lockhart, Chamber of Secrets, Duelling Club. **Scene 2:** Everte Statum, Harry Potter, Chamber of Secrets, Duelling Club. **Scene 3:** Dobby, Lucius Malfoy, Chamber of Secrets, Dobby is free. **Scene 4:** Avada Kedavra, Cedric Diggory, Goblet of Fire, Cedric death. **Scene 5:** Stupefy, Ron Weasley, Order of the Pheonix, Dumbledore's Army.
The equations of motion were taken from 'Physics for Scientists and Engineers' by Tipler and Mosca (2007).

References

[1] `https://www.onaverage.co.uk/body-averages/average-child-weight` [Accessed 1 October 2019]

[2] `https://msis.jsc.nasa.gov/sections/section04.htm#Figure%204.9.3-6` [Accessed 2 October 2019]