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A3_8 "The Garlic Burns a Little-"

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Abstract
This paper investigates whether the character known as the Baron, a vampire of human proportions, can propel himself through the air purely by projectile vomiting from his own mouth, as seen in an episode of the comedy series "What We Do in the Shadows". The calculated thrust of $5.73\text{x}10^{-5}N$ is found to be insufficient in overcoming the relative weight of the Baron at $234.95N$.

Introduction

"What We Do in the Shadows" is a mockumentary focusing on 3 vampires living in modern-day New York. In the episode titled "Baron's Night Out", the leader of the vampires known as Baron the Undying One decides to try some human food in the form of a slice of pizza. This causes him to violently throw up a stream so intense and ongoing that he is launched through the air into the side of a building. This paper will determine whether the parameters of this reaction do in fact create a force strong enough to launch the Baron as seen in the show.

Discussion

Viewing the scene, it's assumed the Baron travels in a straight line from his initial launch site into a point on the building wall approximately 100m away and 40m (3 stories) up. Simple trigonometry therefore calculates a launch angle of 21.8 degrees. The Baron is portrayed by Doug Jones, who's mass is 63.5kg [1], adding 1kg for clothing gives Baron a weight of $64.5g$ where g is acceleration due to gravity. Trigonometry is again utilised to calculate the weight that must be exceeded in order to lift Baron off the ground:

$$64.5gcos(90° - 21.8°) = 23.95g = 234.95N \quad (1)$$

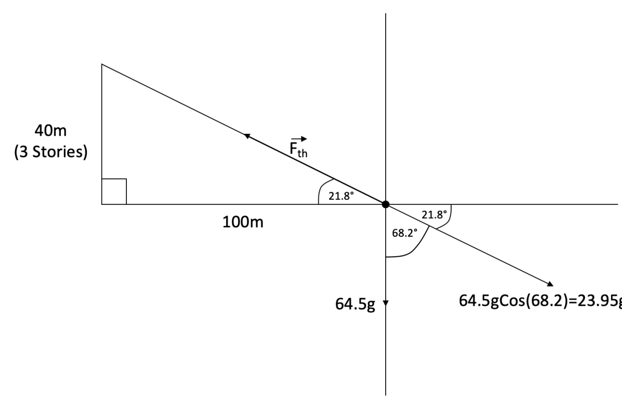

Figure 1: Free body diagram illustrating the distance travelled by and forces acting upon the Baron.

The Baron can be modelled as a rigid-bodied rocket, lending the equations for rocket thrust:

$$F_{th} = -RU_{ex} = -|\frac{dM}{dt}|U_{ex} \quad (2)$$

$$t_b = \frac{M_{fuel}}{R} \quad (3)$$

Where F_{th} is the thrust, $R = \frac{dM}{dt}$ is the rate of propellant lost, U_{ex} is the initial propellant velocity relative to the rocket, t_b is the burn time and M_{fuel} is the mass of the fuel. In this investigation, air resistance is considered to be negligible.

We assume the Baron only eats blood and the one bite of pizza. An average bite size is $12\text{x}10^{-3}kg$ [2]. The density of blood is $994kgm^{-3}$ [3]. The average stomach volume is $10^{-3}m^3$ [4]. Recorded with a stopwatch, the Baron's initial flight lasts 2.67±0.005 seconds, before his stomach reaction reignites and continues to fly for an additional 15.62±0.005s, where it's assumed he uses the remaining contents of his stomach. The initial burn of stomach contents is therefore $\frac{2.67\text{x}100}{(2.67+15.62)} = 14.60\%$. Subsequently, the mass of fuel used is $M_{fuel} = (12\text{x}10^{-3}) + 0.146(994\text{x}10^{-3}) = 0.157kg$. The rate of fuel used in the first burn is $R = \frac{0.157}{2.67} = 0.059$.

In order to calculate the initial velocity of the propellant leaving the Baron's mouth, we must consider fluid dynamics. We assume a laminar flow of a non-viscous fluid. Modelling the Baron's mouth as a perfect cylinder, the velocity of the fluid can be calculated using:

$$v = \frac{\Delta m}{(\rho A \Delta t)} \quad (4)$$

where v is the escape velocity of the propellant, equal to U_{ex}, Δm is the change in mass, in this case our previous value for M_{fuel}. ρ is the density of fluid, A is the cross-sectional area of the cylinder and Δt is the change in time, in this case the burn time.

The density of vomit is taken as the density of one of its components, hydrochloric acid = $1180kgm^{-3}$ [5]. A is taken to be the average male mouth opening = $51.3\text{x}10^{-3}m^2$ [6]. Using $\Delta m = M_{fuel} = 0.157kg$, $U_{ex} =$ $v = \frac{0.157}{(1180(51.3\text{x}10^{-3})(2.67))} = 9.714\text{x}10^{-4}ms^{-1}$. Substituting this into Eq.(2) gives

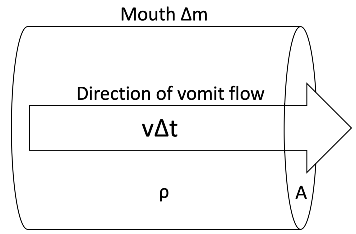

Figure 2: Cylinder demonstrating the flow of vomit through the Baron's mouth.

$F_{th} = -0.059(9.71\text{x}10^{-4}) = -5.73\text{x}10^{-5}N$ relative to the Earth.

Conclusion

The $5.73\text{x}10^{-5}N$ of thrust produced by the stream of vomit during the initial burn time is far less than the Baron's relative weight of $234.95N$. Such a convulsion would sadly not propel the vampire leader off the ground, but would instead create a garlicky mess on his shoes. Further studies could investigate how parameters such as fluid velocity or density would have to change in order to achieve lift-off.

References

[1] `https://www.celebheights.com/s/Doug-Jones-4768.html` [Accessed 29 November 2021]

[2] Mattfeld, R. S., Muth, E. R. Hoover, A.*A comparison of bite size and BMI in a cafeteria setting*, (2017).

[3] Vitello, D. J. et al. *Blood Density Is Nearly Equal to Water Density: A Validation Study of the Gravimetric Method of Measuring Intraoperative Blood Loss*, (2015).

[4] `https://hypertextbook.com/facts/2000/JonathanCheng.shtml` [Accessed 29 November 2021]

[5] `https://mason.gmu.edu/~sslayden/Lab/sws/acid-calc.htm` [Accessed 29 November 2021]

[6] Khare, N. et al. *Normal Mouth Opening in an Adult Indian Population*, (2012).