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A5 2 Could a muggle survive quidditch?

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Abstract

We explore the feasibility of a muggle, who is a non-magical person, surviving a high-speed broomstick flight in the game quidditch (a fictional game), focusing on the Firebolt model, known for its maximum speed reaching 150 mph. The straight-line acceleration was found to exert a force of 0.68 G on the rider. However, a turn with a 5 metre radius to the right would require a banking angle of 89.38° and cause 92.42 G force on the rider. These extreme forces would result in catastrophic physical harm.

Introduction

The Firebolt weighs 3.50 kg [1] and is known for its ability to accelerate from 0 to 150 mph (67.06 m/s) in 10 seconds [2]. We assume the rider's mass to be 78 kg, resulting in a total system mass of 81.50 kg. Quidditch [2] is a fictional sport played by flying at high speeds while executing sharp turns and rapid manoeuvres on broomsticks in an effort to score points. Hogwarts students perform these feats with ease, it raises the question: 'Could a muggle (non-magical person) fly and survive a Firebolt?'.

Flying around

The assumptions made are; the broomstick levitates and flies through the use of magic, the average turning circle radius is 5 metres. This is assumed as Harry Potter takes places in Europe and is compared to a vehicle that is required to have a turning inner turning circle of 5.3 m [3]. As shown in Figure 1.

To determine the broomsticks average acceleration, we use the top speed, 67.06 m/s, and the time to reach this speed is 10s, giving an average acceleration of a = 6.71ms^{-2}. The G-force on the rider under acceleration can be calculated (ratio of the force experienced by the rider and their weight) using $Gforce = a/g$, where g is the gravitational constant, 9.81 ms^{-2}. The G force experienced when accelerating in a straight line is 0.68 G.

We also consider whether the rider would be able to stay on Firebolt at maximum speed by calculating drag forces experienced:

$$F_d = \frac{1}{2}\rho v^2 C_d A \tag{1}$$

Where F_d (N) is the force due to drag, ρ is air density (ρ = 1.225 kgm^{-3}), v is the velocity of the broom relative to the air (assuming no wind and speed remains constant, v = 67.06 ms^{-1}), C_d is the drag coefficient ($C_d = 0.6$), this is the approximate C_d of a person on a push bike [4], which is a similar sitting position to a broomstick. The assumptions made are; a person is roughly rectangular in this position, with a seated height of 1.275 m and a width of 0.37

m and an average height and shoulder width [5]. A is the cross-sectional area of the rider and is calculated to be $A = 0.472$ m^3. Therefore, the drag force is calculated to be 780.06 N.

As the rider banks to turn to the right with a constant maximum velocity, a centripetal force is produced normal to the bank angle and is calculated with the following equation:

$$F_{cf} = \frac{m_s v^2}{r}, \tag{2}$$

where r is the radius of the turn ($r = 5$m) and m$_s$ is the mass of the system. The F_{cf} produced is approximately 73.30 kN and The banking angle can also be calculated:

$$\theta \ = \tan^{-1}(\frac{v^2}{rg}), \tag{3}$$

the banking angle is found to be 89.38° and this is the angle at which a vehicle becomes inclined with respect to the horizontal around its longitudinal axis, using this result the G force of the turn can be calculated; G force = $1/\cos\theta$. The G-force experienced by the rider is 92.42 G.

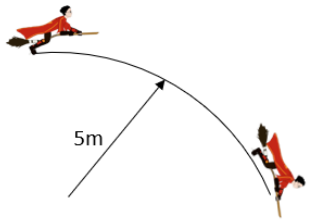

Figure 1: The rider turning with a radius of 5m [6]

Discussion

The forces acting on the rider are significant, such as 92.42 G when making a turn, with a human only able to survive on average 4-6 G [7]. The banking angle also shows the broomstick must tilt almost vertically at 89.38° to make a tight turn, and this steep angle could lead to the rider falling off. The force experienced whilst the muggle is travelling through the air in a straight line, would approximately be 780.06 N, which is manageable as motogp riders experience more force as they travel at higher speeds [8]. If a muggle travels at 67.06 ms^{-1} the G-force would be 0.68 G whilst accelerating from A to B, which is survivable for a muggle as they experience an average of 0.70 Gs on a commercial flight [9].

Conclusion

A muggle would not survive a quidditch game. No human would be able to withstand 92.42 Gs, for example, fighter jet pilots can only experience 9 Gs for a few seconds. However, if a muggle uses the broomstick solely for travel with no sharp turns, the experience would be comparable to flying on a plane.

References

[1] https://noblecollection.co.uk/product/the-firebolt/ [Accessed 28 Oct. 2024].

[2] https://harrypotter.fandom.com [Accessed 28 Nov. 2024].

[3] https://www.hse.gov.uk/workplacetransport/vehiclehandling.htm [Accessed 28 Oct. 2024].

[4] https://blog.flocycling.com/aero-wheels/flocycling-studying-tires-part-7-solving-for-cda-1/. [Accessed 28 Oct. 2024].

[5] https://www.bbc.co.uk/news/uk-11534042. [Accessed 28 Oct. 2024].

[6] https://www.downloadclipart.net/browse/102246/harry-potter-broom-png-clipart-clipart [Accessed 28 Oct. 2024].

[7] https://www.sciencefocus.com/science/whats-the-maximum-speed-a-human-can-withstand [Accessed 28 Oct. 2024].

[8] https://www.motogp.com/en/news/2021/03/18/what-is-the-official-outright-motogp-speed-record/165090. [Accessed 29 Oct. 2024].

[9] https://www.skycombatace.com/blog/human-body-g-force [Accessed 29 Oct. 2024].

[10] Rowling, J.K., Harry Potter series (1997-2007)