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A2_4 Murderous leaf

T. Bhaad, E. Dickens, D. Anderson, S. Limbu

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

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Abstract

Can a regular leaf prove to be fatal for a human being if Earth were to switch its wind speed with the planet Uranus? In this paper fundamental physics is applied, and the time taken for a leaf to pierce through the skin to reach the bones is calculated to be 0.29 s at the wind speed 40 ms^{-1}. The air resistance faced by the leaf is 0.162 N which is expected to be a small value since it is proportional to the area of the object.

Murderous leaf

A leaf could potentially prove to be fatal to a person sitting in a park bench if Earth switches wind speeds with Uranus.For an air borne leaf, aerodynamic forces direct the velocity and the time it would take for the leaf to penetrate through the skin.

Assumptions and constants

The wind speed at Earth on a usual day ranges from approximately 3 ms^{-1} to 5.51 ms^{-1}[1] but on Uranus, the average wind speed is around 40 ms^{-1}[2]. A stationary individual is considered for the situation's relevance. The person is considered to be sitting on a park bench at a certain distance from a tree and the tip of the leaf comes in contact with their skin. The leaf is considered to be indestructible to some degree with a mass of approximately 0.03 kg [3] and a diameter of 0.07 m [4].The density of air is taken to be 1.20 kg m^{-3} [5] at 20° C. The drag coefficient for the leaf which is a streamlined shaped body is 0.04 [6].

Method and equations

It would take the leaf a combined total of 169.85 N to pierce through to the persons bone. It takes 74.35 N to pierce through a hoodie and a t-shirt [7] and 95.50 N to pierce through the skin, fat and muscle of a human [8]. The following equation can be used to calculate the time taken for the leaf to penetrate to the bones.

$$F = \frac{mv}{t} \tag{1}$$

Where m is the mass of the leaf in kg, v is the velocity of the air borne leaf in ms^{-1} , F is the force required in N and t is the time required by the leaf. After calculating the time t the formula below is used to calculate the distance d required for the airborne leaf to travel to pierce through to a person's bones.

$$v = \frac{d}{t}, \tag{2}$$

After calculating the distance (m) the leaf needs to travel, air resistance for the leaf in motion is calculated using the equation:

$$F_d = \frac{1}{2}\rho v^2 C_D A, \tag{3}$$

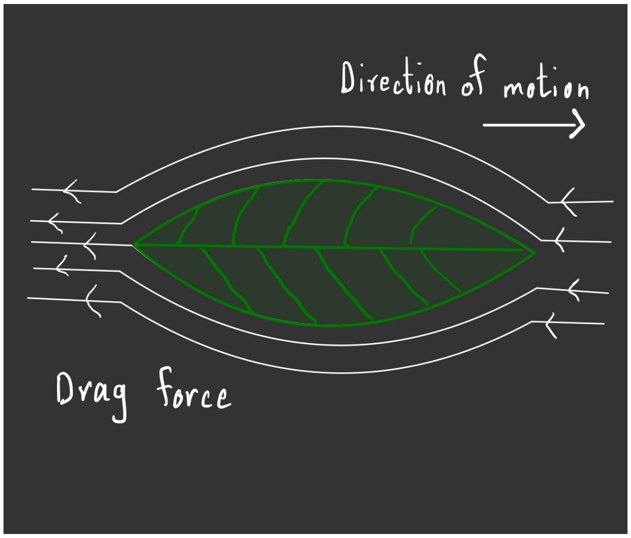

Figure 1: Drag force on the leaf

where F_d is the air resistance or drag force in N [9], ρ is the density of air kgm^{-3} , C_D is the drag coefficient and A is the cross sectional area in m^2 . In this case we calculate the area of the leaf which a streamlined shaped body using the formula:

$$A = \frac{1}{4}\pi d^2, \quad (4)$$

Where d is the diameter of the leaf in m. Taking the drag force into consideration the total net force F_t, can be calculated using:

$$F_t = F - F_D, \quad (5)$$

Results

It takes the leaf 0.29 s (equation 1) at the wind speed of 40 ms^{-1} to apply a force of 169.85 N to pierce through to the bones of a human being. The leaf would have to travel for 11.60 m (equation 2) to cause fatal damage to a human being at a stationary position for instance, sitting on a bench or standing. The leaf experiences an air resistance of 0.16 N which is not a significant deterrent considering the velocity with which it is travelling. The total net force after taking the drag force or air resistance into consideration would be 169.69 N.

Conclusion

Realistically, a leaf could potentially prove to be fatal during intense storms on Earth if a person was stationary, which is highly unlikely because a wind of that magnitude would knock an average sized person over. However if a person was to go outside and be stationary, for instance sitting on a bench in the park while a wind of over 40 ms^{-1} (Uranus's wind speed) is blowing, it is possible to get severely injured by an airborne leaf.

References

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