

## Head in the Clouds: The Aerodynamics of Doraemon's Take-Copter

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### Abstract

Doraemon is a Japanese manga series, later adapted into an anime TV series, that tells the story of a robotic cat from the 22<sup>nd</sup> century that travelled back in time to save his great-great-grandfather, Nobita Nobi, from ruining their family lineage. This futuristic cat is equipped with a front pocket that's capable of producing gadgets used throughout the series to save the day. This paper aims to examine one of these gadgets, the Take-Copter, and analyse the realistic limits of this gravity-defying gadget.

**Keywords:** Manga; Physics; Aerodynamics; Mechanics; Doraemon; Take-Copter

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### Introduction

Doraemon's [1] pocket stores an infinite number of gadgets from the 22<sup>nd</sup> century. Typically, Nobita finds himself in a predicament, prompting Doraemon to search through his pocket to find an appropriate gadget to resolve the situation. One that often appears throughout the manga is the Take-Copter, a compact, battery-powered apparatus that attaches to the user's head and enables flight [2]. However, as seen in *Figure 1*, it is clear that the propeller is too small to generate any meaningful kind of lift.



Figure 1 – Image from the 2005 animated series, Doraemon, featuring the main characters using the Take-Copter to fly. From left to right: Suneo Honekawa, Nobita Nobi, Doraemon, Shizuka Minamoto and Takeshi "Big G" Goda [3].

### The Take-Copter

The Take-Copter employs a rotor system intended to generate lift through aerodynamic interaction with the surrounding air. For successful flight, the generated lift force must be greater than the weight

of the object. For this analysis, Nobita, who is ten in the manga, will be used as the main framework of the equations. The average mass of a ten-year-old lies between 24-46 kg [4]. Nobita's mass will be assumed to lie at the midpoint at 35 kg. The gravitational force acting on the body can be calculated using [5]:

$$F = mg, \quad (\text{Eq}^n 1)$$

where  $m$  denotes mass and  $g$  is the gravitational acceleration. Substituting the assumed values yields:

$$F = 35 \times 9.81 \approx 343 \text{ N}.$$

Thus, the rotor system must generate a minimum of 343 N of upward force. The aerodynamic lift produced by the rotor is given by [6]:

$$L = \frac{1}{2} \rho v^2 A C_L, \quad (\text{Eq}^n 2)$$

where  $L$  is lift,  $\rho$  is air density,  $v$  is the air velocity relative to the blade,  $A$  is the rotor disk area, and  $C_L$  is the lift coefficient.

The Take-Copter has two blades, as pictured in *Figure 2*, with a 20 cm diameter [7]. The rotor disk area refers to the circular area swept by the rotating blade, which can be found using the formula:

$$A = \pi r^2, \\ A = \pi \times 0.01^2 = 3.14 \times 10^{-4} \text{ cm}^2.$$

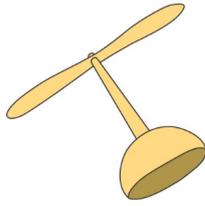


Figure 2 – An image of the stationary blades of the Take-Copter [8].

To estimate the air velocity at the blade tip, the relationship between angular velocity ( $\omega$ ) and rotational speed (RPM) is used [5]:

$$\omega = \frac{v}{r}, \quad (Eq^n 4)$$

$$RPM = \frac{\omega \times 60}{2\pi}. \quad (Eq^n 5)$$

Rearranging these expressions yields:

$$v = r \times \frac{2\pi \times RPM}{60}$$

Using experimentally estimated rotational speed of 5720 RPM [9], results in:

$$v = 0.01 \times \frac{2\pi \times 5720}{60} = 5.9 \text{ m s}^{-1}.$$

Assuming standard air density at sea level ( $\rho = 1.225 \text{ kg m}^{-3}$ ) and approximating  $C_L = 1$ , substitution into Equation 2 gives:

$$L = \frac{1}{2} \times 1.225 \times 5.9^2 \times 3.14 \times 10^{-4} \times 1,$$

$$L \approx 6.69 \times 10^{-3} \text{ N}.$$

This result corresponds to an upward force of 0.0067 N, which is several magnitudes smaller than the required 343 N. Using the same assumptions, the rotor diameter necessary to generate sufficient lift would be approximately 2.3 m, over 200 times larger than what is depicted in the manga. Alternatively, it would require a rotational speed of approximately 1.3 million RPM, which is 64 times the speed of race car engines [10].

### A Real Pain in the Neck

In addition to the aerodynamic limitations, the Take-Copter introduces a significant biomechanical challenge. The Take-Copter is mounted directly on the user's head, meaning that the generated lift force is transmitted through the cervical spine. Consequently, the entire body weight must be supported through the neck, producing a tensile load along the longitudinal axis of the spine, commonly referred to as axial tension. Biomechanical studies found that a ten-year-old can withstand forces of 285N [11, 12]. Under these conditions, Nobita's

weight would exceed the limits of his spine capacity, resulting in critical injury.

However, the manga depicts characters flying with their bodies oriented horizontally relative to the ground, thereby mitigating concerns about spinal overload. This introduces a new problem.

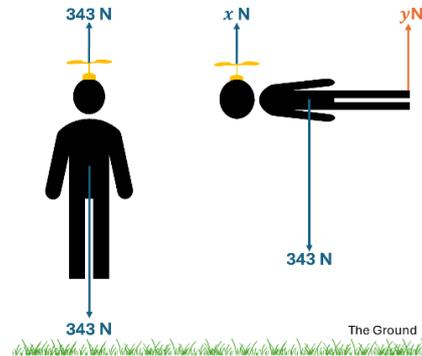


Figure 3 – A free body diagram of the forces acting on Nobita flying vertically (left) or horizontally (right), where  $x$  and  $y$  must sum to 343 N (image created by author).

As seen in Figure 3, as they fly parallel to the ground, an additional force is required to keep them horizontal and counteract the torque generated by the displacement between the point of lift and the body's centre of mass. The Take-Copter and the additional source must provide a total upwards force of at least 343 N. The magnitude of the force will also depend on its distance from the body's centre of mass.

Thus far, the calculations show that the Take-Copter is incapable of making anyone fly. It could be theorised that there is a hidden mechanism brought back from the 22<sup>nd</sup> century that generates the required lift.

### Conclusion

The Take-Copter, as depicted, is neither sufficiently large nor capable of generating the aerodynamic forces required to produce the lift necessary for human flight. Furthermore, the device appears incapable of sustaining either vertical or horizontal flight under conventional physical constraints. These limitations suggest that the Take-Copter alone cannot account for the observed behaviour of the device. Instead of the primary source of propulsion, the Take-Copter could serve as an illustrative aid for the reader. The rotor system provides an intuitive representation of flight, while the true force generation may be a concept beyond current scientific understanding.

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