5-1-2013

Helicopter toy and lift estimation

Said Shakerin
University of the Pacific, sshakerin@pacific.edu

Follow this and additional works at: https://scholarlycommons.pacific.edu/soecs-facarticles

Part of the Mechanical Engineering Commons

Recommended Citation
https://scholarlycommons.pacific.edu/soecs-facarticles/86

This Article is brought to you for free and open access by the All Faculty Scholarship at Scholarly Commons. It has been accepted for inclusion in All Faculty Articles - School of Engineering and Computer Science by an authorized administrator of Scholarly Commons. For more information, please contact mgibney@pacific.edu.
Helicopter Toy and Lift Estimation

Cite as: Phys. Teach. 51, 310 (2013); https://doi.org/10.1119/1.4801367
Published Online: 08 April 2013

Said Shakerin

ARTICLES YOU MAY BE INTERESTED IN

Investigating Flight with a Toy Helicopter
The Physics Teacher 48, 458 (2010); https://doi.org/10.1119/1.3488189

Toy helicopters and room fans
The Physics Teacher 49, L2 (2011); https://doi.org/10.1119/1.3624487

Wilberforce pendulum oscillations and normal modes
American Journal of Physics 59, 32 (1991); https://doi.org/10.1119/1.16702
Therefore, the average speed of the propeller \((V)\), at midpoint between the center and tip of the propeller, is:

\[
V = \frac{\omega R}{2} = 133 \text{ rad} \cdot \left(\frac{0.1 \text{ m}}{2}\right) \approx 7 \frac{\text{m}}{\text{s}}.
\]

The lift \((L)\) depends on speed \(V\), planform area \(A\), air density \(\rho\), and coefficient of lift \(C_L\), which is a function of angle of attack and the shape of the propeller. The lift formula and coefficient of lift can be obtained from any aerodynamics textbook. Based on aerodynamics data, assuming 1 for the coefficient of lift is a reasonable estimate for the toy’s propeller and its angle of attack.

Therefore, the estimated lift (0.1 N) is sufficient to overcome the weight (0.07 N).

It should be noted that the estimated lift is probably conservative because square of average speed was used in the above equation. The correct procedure involves integration of the square of local speed, which varies with radius, over the length. A simple way to more accurately represent the effect of integration would be to use speed at 0.75 \(R\) rather than at 0.5 \(R\) in the above equation. Also, estimation of spin duration is critical. Because it happens so fast, it cannot be obtained just by unassisted watching. As mentioned earlier, a simple way to do this is by extracting the spin duration from replaying a video recording of the launch.

After this estimation, a more challenging problem could be assigned: estimate the flight time. One would need to consider propeller drag and minimum speed to cause a lift equal to weight, among other issues for that estimation.

A design firm, Lufdesign.com, recently has developed a prototype named FlyingStick based on this toy that has a five-blade propeller and an integrated camera at the bottom of its stem. Powered by hand, as with our plastic toy, the FlyingStick takes continuous photographs of its field below while flying. The camera has a stabilizer to compensate for a wide range of shake and spin frequencies for optimal focusing.

**Acknowledgment**

The author is grateful to the anonymous reviewer for insightful comments that improved the article.

Said Shakerin, Department of Mechanical Engineering, University of the Pacific, Stockton, CA 95211; sshakerin@pacific.edu