XXXXX Science
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08 September 2024

Effects of Wingspan and Mass on Rotocopter Fall Time

INTRODUCTION

Research Topic

Rotocopters as devices for prolonging falls.

Research Question

This report seeks to answer and before that posits this question: What is the effect of the wingspan of a rotocopter on its fall time and the mass of the rotocopter on its fall time?

Background

Rotocopters are tools that have two upper blades facing opposite directions (to produce drag and slow the descent of the rotocopter), and a lower stalk (to aid in the stability of the rotocopter.

Rotocopters are mechanisms that utilise the surface area of their wingblades to produce drag, slowing their descent and reaching the ground at safe speeds. They do this by using their blades to redirect air in opposite directions. A side effect of this is that the rotocopter will rotate in the air, as the redirection of air in order to slow descent results in torque applied to the rotocopter's shaft. It is no surprise, then, that rotocopter and rotate both share the root word *rota*, which is *wheel* in Latin.[1]

Naturally, given this understanding of the mechanics we can understand that variables relating to the rotocopter that may affect its length of fall include its mass, the size of the wing, and the tilt of the wing. This is because mass is involved in the gravity that pulls it down, the size of the wing affects the drag and how much air is displaced, and the same rationale applies to the tilt of the wing. Rational guesses and the understanding of the mechanics of rotocopters allow us to hypothesise the effects of these various variables on the length of fall. However, for the limited scope of this experiment, time will only be tested against length of fall and mass.

Rationale

This data, and as an extension of that data in this report, only exists because **XXXXX** has forced me to do this. This is commonly known outside of this paper as a "school assignment", and this practice appears to be exceedingly and unsurprisingly common in many parts of the world.

Hypothesis

Wingspan directly positively correlates with fall time, whereas Mass negatively affects it.

This is due in part to an analysis of the rotocopter within the view of the forces affecting flight (Drag, Lift, Thrust, and Gravity). Gravity is exacerbated by mass, and both lift and drag are exacerbated by wingspan. A higher gravity would result in shooter falls, and higher drag and lift would result in longer falls.

VARIABLES

Independent Variable

Independent variables modified by the experiment include mass and wingspan.

Mass is manipulated by adding on paperclips to the rotocopter, and measured with a scale (precise to 0.01g).

Wingspan is manipulated by folding in the wings so as to not alter mass, and measured with a ruler (precise to 1 mm).

Dependent Variable

The dependent variable central to this experiment is time, measured in seconds with a stopwatch (precise to 0.01 seconds).

Controlled Variables

Controlled variables include tilt of the wing (kept stable by simply not altering it), rotocopter mass (kept stable by not altering the rotocopter), and rotocopter wing width (kept stable by not altering the rotocopter). Most controlled variables surrounding the rotocopter were kept stable this way; simply by not altering them. Attempts were made to control air pressure, temperature, and wind by performing the experiments in such a short time frame that they would not be able to change. Other variables controlled include height of drop, which was achieved by dropping the rotocopter from the same spot to the same ground consistently each time. This in turn was achieved by dropping the rotocopter from a point parallel to a bannister at the second floor of the school building to the same ground. Only vertical drop distance was controlled, natural horizontal or depth-wise drop distance was attempted to be controlled and could not due to the consistent unpredictability inherent in the rotocopter.

METHODOLOGY

Materials

- Paper
- Stopwatch
- Ruler
- Paperclips (0.42 g)
- Scale

Safety, Ethical or Environmental Issues

The primary dangers to safety in this experiment come from (as always) human error. Most notably, proper procedure involving stairs was a mandate to avoid personal injury. Fortunately, all stairs involved in the experiment were fitted with handrails, as required in Section 3.4.6.6. of Division B of the National Building Code of Canada: 2020.[2] So too were bannisters (see Section 9.8.7.1.). Any dangers this facility could have posed were directly quelled and directly answered by the National Building Code. There are few safety precautions meant for the ascent and descent of stairs. This is because such safety precautions are expected to be common sense for mature individuals. In this world, no one can assuredly be a mature individual; there must always be an ounce or greater of doubt in the mind. It was imperative that experimenters did not run up stairs, and that they kept aware of our surroundings. So long as common sense was followed, no harm could befall facilitators of the experiment.

Ambitious as it is to say, no ethical concerns are raised by this experiment. No harm is done by it, no distress caused~~ - it can be said to be perfectly moral~~.

Some may raise environmental concerns of this experiment in misuse and waste of paper. Solidly, however, it must be said that the paper used in this experiment can and will eventually be used for another purpose. The paper has already been made. The damage was already done.

Ultimately, this experiment contributes negligible impact against the environment, significantly less than the harm done consistently and constantly by monolithic corporations on a daily basis.

Experimental Procedure

1. A rotocopter is made in accordance with this sheet: https://www.csuchico.edu/gateway/_assets/documents/ma-lesson3.pdf (printed on A4 paper).

2. A designated amount of paper clips are attached to the shaft of the rotocopter.

3. The rotocopter is raised to a designated height.

4. The rotocopter is dropped from the designated height and a stopwatch starts.

5. The rotocopter hits the ground and the stopwatch stops elapsing time.

6. The stopped time on the stopwatch and the amount of paper clips are recorded on a sheet of paper.

7. Steps 2-6 are repeated with different amounts of paper clips as needed.
8. The wings of the rotocopter are folded such that the horizontal section is a designated length and the remainder is perpendicular to that designated length of wing.

9. The rotocopter is raised to a point 447.5 cm above the ground.

10. The rotocopter is dropped and a stopwatch starts elapsing time.

11. The rotocopter hits the ground and the stopwatch stops elapsing time.
12. The stopped time on the stopwatch and the length of the unfolded wing are recorded.
13. Steps 8-12 are repeated with different lengths of wing as needed.

DATA AND ANALYSIS

Table A.

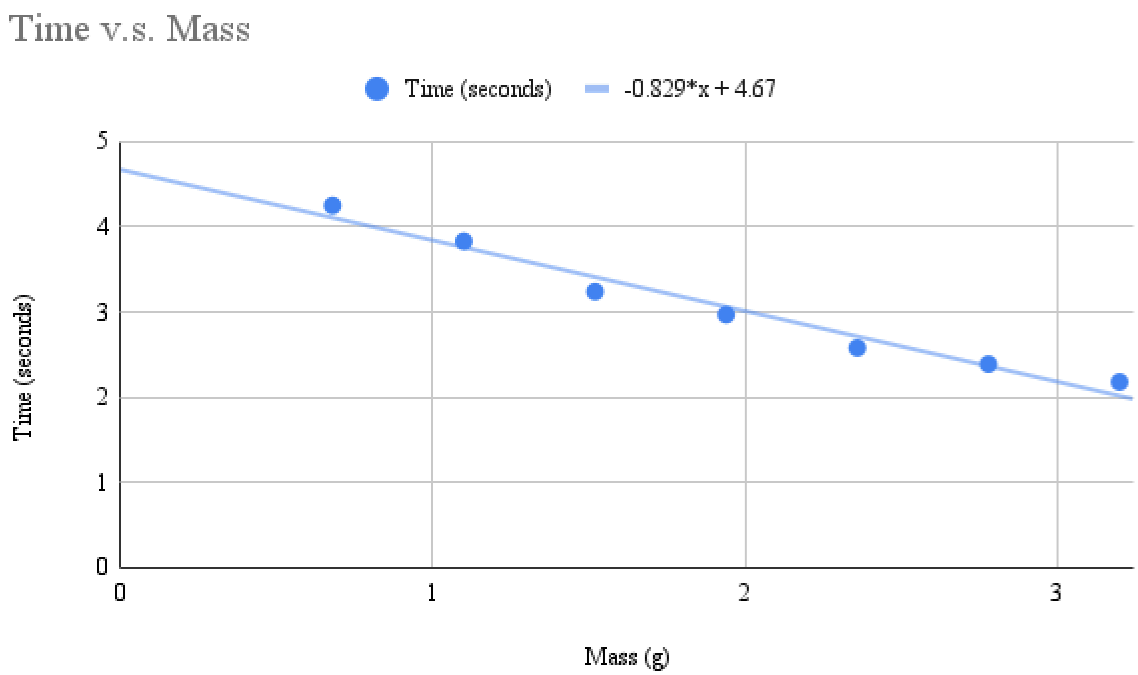
Rotocopter (g)	Paperclip (g)
0.68	0.42

Table A includes weight measurements used to calculate the total mass of the various rotocopters (with the rotocopters affixed to them) in Table B. These measurements were taken with a scale precise to a hundredth of a gram.

Table B.

Time v.s. Mass	
Mass (g)	Time (seconds)
0.68	4.25
1.1	3.83
1.52	3.24
1.94	2.97
2.36	2.58
2.78	2.39
3.2	2.18

Graph C.



(Trendline: time=-0.829(mass)+4.67)

Data used for Graph C and Table B come from steps 2-7 of the procedure and weight data from Table A.

Graph C showcases a strong negative correlation between mass and fall time.

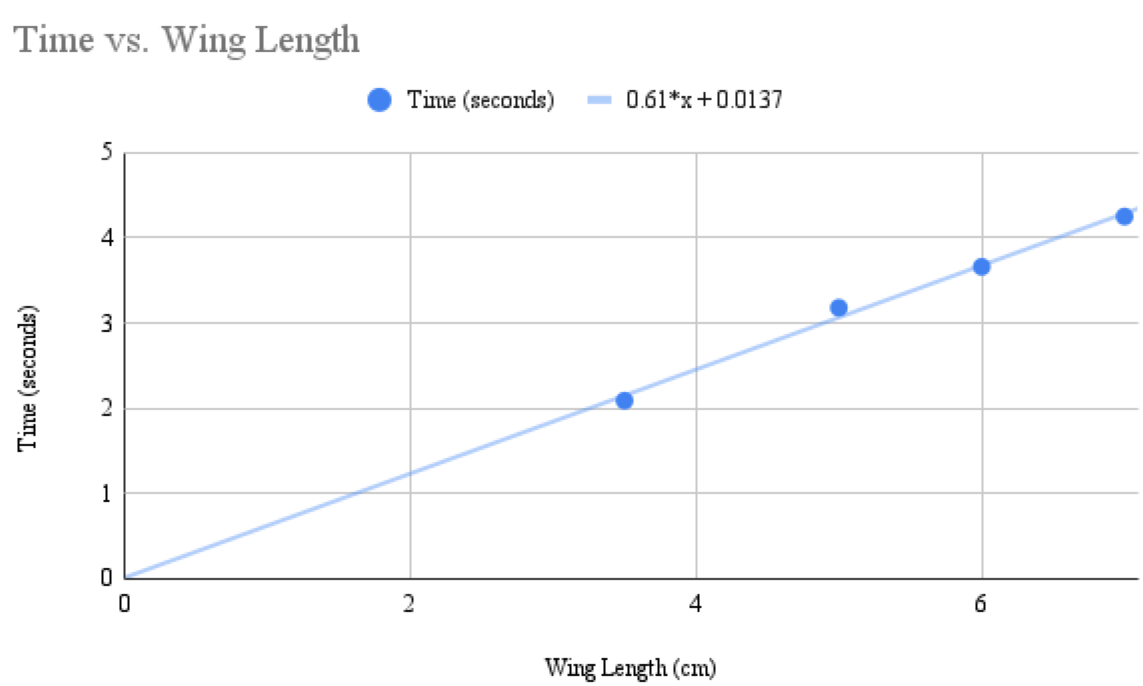
Table D.

Time v.s. Wing Length	
Wing Length (cm)	Time (seconds)
7	4.25
6	3.66
5	3.18
3.5	2.09
2	

All wing lengths spun properly with the exception of wing length 2 cm (and likely all wing lengths below it) which did not spin and which we were unable to get a proper time measurement of due to its largely irregular and wayward path.

This table, aside from demonstrating (with Graph E.) a positive correlation between wing length and time, also demonstrates through the Spin column the fact that rotocopters have a more stable flight path when spinning.

Graph E.



(Trendline: time=0.61(wing length)+0.0137)

Data used in Table D and Graph E both came from steps 8-13 of the procedure. Graph E showcases a strong positive correlation between wing length and fall time.

Table G.

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[3]

CONCLUSION AND EVALUATION

Conclusion

Table B and Graph C (time=-0.829(mass)+4.67) clearly represent a negative relation between mass and time with high correlation.

Table D and Graph E (time=0.61(wing length)+0.0137) clearly represent a positive relation between wingspan and time with high correlation.

Evaluation

This report seeks to find the effect of the wingspan of a rotocopter on its fall time and the mass of the rotocopter on its fall time and predicts that wingspan would cause an increase and mass would cause a decrease. The results in Graph E clearly represent a positive relationship between wingspan and fall time and a negative relationship between mass. The spin keeps the rotocopter slowly falling by allowing the wings to catch the air and by keeping them straight with what is likely centrifugal force. The results in Graph C evidently represent a negative relationship between the mass of the rotocopter and the duration of the fall. The additional mass causes the rotocopter to fall faster by allowing gravity to exert a greater force on the rotocopter. Of course, none of this data is truly substantial, it only demonstrates, and cannot prove. These results do, however, support the hypothesis as they demonstrate that the behaviour posited in the hypothesis is an accurate prediction of the behaviour of the rotocopter in reality. This relationship between the independent variables and dependent variables exists because of the mechanics of the rotocopter and gravity.

This investigation, like all investigations, contains flaws and strengths. Its strengths come from its easy reproducibility, its low cost of procedure, and its simplicity which lends itself to use in classrooms as an educational tool for the young and underexposed-to-lab-work. Its flaws come from its consistent imprecision, reliance on constantly erroneous humans, and the difficulty of precise reproduction. Most errors in the data arise from human error, slight imprecision in manufacturing of the rotocopters, or a combination of the two. Many other errors arose because the rotocopter was damaged during a drop and ceased to function properly. (e.g. falling in a non-straight path, ceasing to spin, etc.) Error could also have been generated from variables that could not be properly or feasibly controlled, such as air pressure, temperature, wind, path of flight, etc. At any rate these errors are both consistent and do not take up any significant proportion of the measurements, and so would not meaningfully or significantly affect the core conclusions that this experiment finds, which are the correlations between wingspan and mass and drop length.

Furthermore, none of the data gathered from these experiments meaningfully prove anything concrete about the behaviour and mechanics of rotocopters. All they can meaningfully do is present correlations between the chosen independent variables and dependent variables. The improvement of this experiment could be facilitated by a more precise method of rotocopter production, more precise forms of measurement, a more sturdy rotocopter design, and additional measures that would allow for greater accuracy including a more standardised drop height.

Of course, to strive for perfection is to strive for greatness.

~~The only reward is failure.~~

BIBLIOGRAPHY & FOOTNOTES

[1] “Rota Definition & Meaning.” Merriam-Webster, Merriam-Webster, www.merriam-webster.com/dictionary/rota. Accessed 6 Sept. 2024.

[2] National Building Code of Canada 2020. Canadian Commission on Building and Fire Codes, 2020.

[3] Aside from the header, this page was entirely burnt.