# Calculating a fighter pilot's safe weapon system release altitude using Python

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## Introduction

Pilot safety is an important consideration in any planned military operation. A program was created using Python that took various flight parameters into account to calculate the altitude that is safe for a fighter pilot to release their weapon system and exit a dive. The effectiveness of a weapon system is dependent upon the release altitude along with other parameters at the point of delivery. When a fighter pilot releases a weapon system, such as a missile, the extreme gravitational forces exerted by the acceleration and angle of descent can be harmful to the pilot (Forster, Rogers, & Whinnery, 2014). Gravitational force ($g$) is a form of acceleration that causes the fighter pilot to experience a force acting in the opposite direction of acceleration. A fighter pilot can typically function normally at gravitational forces lower than 4.5 $g$'s; however, exposure to gravitational forces greater than this can cause the pilot to experience a temporary loss of consciousness (G-LOC). Early symptoms of G-LOC include tunnel vision or disorientation which could eventually result in a loss of consciousness (Richard, & Stott, 2013). Current programs focus on determining the optimal altitude at which a weapons system should be released to maximize the systems damage. However, these programs fail to consider the potentially harmful effects of $g$-force the fighter pilot experiences when they are pulling out of a dive. Using this program, a pilot could determine at which altitude a maneuver could be safely executed.

## Materials and Methods

The parameters necessary for the fighter pilot to perform a successful launch of their weapon system were identified (Figure 1). An equation was then derived using these variables to calculate the starting altitude of a fighter pilot for a successful dive (Figure 2). The equation was then evaluated for multiple values of gravitational force ($g$) to determine a range of starting dive heights ($y$).

An integrated development environment (IDE) was used to simplify the coding process. This project incorporated the use of the IDE, JupyterLab, as it is flexible and can handle large amounts of data.

A graphical user interface was developed, that allowed the fighter pilot to input values for the variables and provided an easily understood output (Figure 3). Results of the initial program were compared to real world data to determine the accuracy of the calculations.

## Materials and Methods (cont.)

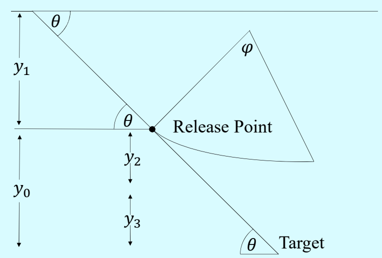
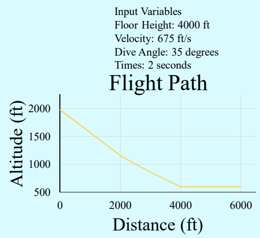



Figure 1 (left): The drawing used to derive the equation to calculate the starting altitude.

$$y = \frac{v^2}{Kg}\sin\theta + y_3 + vt_1\sin\theta$$

Figure 2 (left): This equation was created to calculate starting altitude taking into account velocity ($v$), force of gravity ($g$), time($t$), dive angle ($\theta$), and a calculated constant ($K$).




| #$g$'s experienced | Starting Altitude (ft) |
|---|---|
| 2.0 | 2540 |
| 2.5 | 2337 |
| 3.0 | 2201 |
| 3.5 | 2104 |
| 4.0 | 2032 |
| 4.5 | 1975 |
| 5.0 | 1930 |
| 5.5 | 1893 |
| 6.0 | 1863 |
| 6.5 | 1836 |

Figure 3 (left): A sample of the graphical user interface (GUI) output. The graph represents the flight path of the dive.

## Results

The altitudes calculated by the program were analyzed by comparing them to real-world data using a paired $t$-test.

The results of the paired $t$-test showed that there was a significant difference in starting altitude between the real-world data ($M$ = 3177, $SD$ = 527) and the program data ($M$ = 3267, $SD$ = 638), $t(40)$ = −2.53, $p$ = 0.015. The mean difference in starting altitude was 90 ft with a 95% confidence interval range from −161.4 to −18.1. Using the alpha level of 0.05 the null hypothesis was rejected suggesting that the mean starting altitude calculated using the Python program was not equal to the mean starting altitude from real-world data.

The box plot in Graph 1 displays the difference in the data generated by the Python program and the actual starting altitudes collected from real-world data. Despite the range of the two data sets (real-world data = 2039 ft, program data = 2027 ft) being similar, the most noticeable difference was that the starting altitudes from the Python program were generally larger.

## Results (cont.)


Graph 1 (left): The box and whisker plot compares the real-world results and program output for the 40 analyzed cases. Negative numbers represent overestimates by the Python program compared to paired values from real-world data.

The initial altitudes calculated by the Python program at dive angles under 25 degrees were lower than the real-world data at floor altitudes above 450 feet. Conversely, the program consistently calculated higher starting altitudes for dive angles of 30 degrees when the floor altitude was less than 550 feet. These differences could be attributed to factors that were not accounted for in the Python program.

## Conclusion

The purpose of this project was to create a program that could accurately provide a fighter pilot a safe altitude in which a weapon system could be released without causing any harm to the fighter pilot. The initial height in which the fighter pilot should start a dive was not successfully calculated. Future research could include refining the equation by implementing lift and drag and by expanding the program to include additional maneuvers. This work would provide critical mid-flight information to pilots allowing them to make flight path decisions by taking into account the $g$-force they would experience given different dive starting altitudes. The aerodynamics of the aircraft could also be incorporated into the formula.

## References

Forster, M. E., Rogers, B. P., & Whinnery, T. (2014). The +Gz recovery consciousness curve. *Extreme Physiology and Medicine, 3*, 1–10.

Richard, J., Stott, R. (2013). Orientation and disorientation in aviation. *Extreme Physiology and Medicine, 2*, 1–11.