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P5_3 Pigs on the Wing

Benham, T. J., Foxcroft, B., Dodds, C. J. C., Waters, S. J. W

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

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Abstract

In this article we explore the wind speed required for a pig to fly, and calculate the time taken for a pig to reach a height above the Battersea Power Station (101 m), as seen on the Pink Floyd Album *Animals*. We found that the minimum wind velocity required to lift a 70 kg pig 101 m, is 20.4 ms^{-1}. Assuming there is a severe gale wind velocity of 24 ms^{-1}, we find that it would take 7.3 s to reach this height, assuming only vertical movement.

Introduction

As seen on the front cover of the Pink Floyd album *Animals*, a pig is depicted flying over Battersea Power Station. In this paper we study the conditions needed for a standard farmyard pig [1] to take off when attached to a Falcon 4 hang glider [2]. Moreover, we then determine how long the pig would take to reach an altitude equivalent to that of Battersea Power Station (101 m) [3].

Theory

For aircraft to fly successfully, the air velocity over the top of the wing needs to be larger than that below, usually this is done by giving the aircraft a velocity causing air to flow over the wings. However in our calculations, we have kept the pig stationary and are assuming strong winds are acting on the pig and glider. This results in a lower pressure on top of the wing, which in turn provides a lift force, as given by Equation (1) [4],

$$F_l = (m^2 - 1)\frac{A\rho v^2}{2}. \quad (1)$$

Assuming that air acts as an incompressible fluid and travels m times faster over the top of the wing than below, a lift force is seen. Further, we assumed an ideal aerofoil design such that: m is a constant, 1.1; A is the hang glider surface area; 15.8 m^2; ρ is the density of the air (assumed to be 1 kgm^{-3}); v is the wind velocity. A graph of the force of lift against wind velocity was produced, as shown in Figure 1.

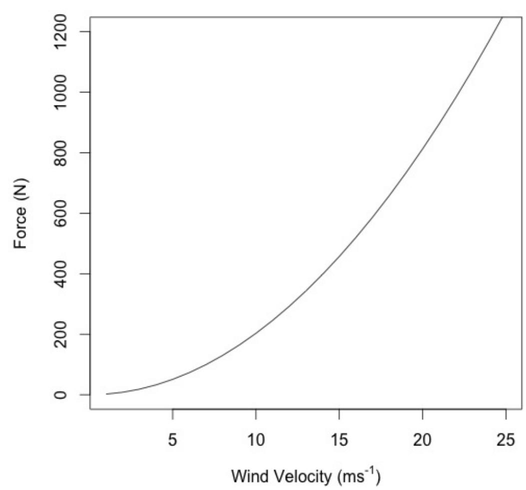

Figure 1: This figure shows the relationship between the lift force and the relative wind velocity. The parabolic curve arises due to the square relationship between these variables.

For the pig to fly, F_l must be greater than the weight of the pig, F_w, as shown in Equation (2).

$$F_w = M_{pig}g \quad (2)$$

A relationship between wind velocity v and pig mass M_{pig} is made by equating F_l, Equation (1), and F_w, Equation (2), and dividing through by g (gravitational acceleration). Figure 2 shows this, again a parabolic relationship.

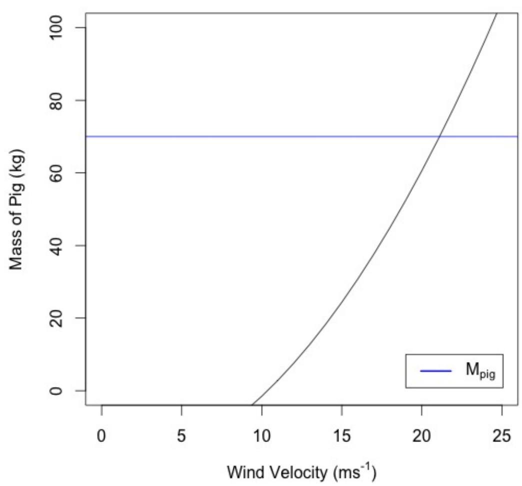

Figure 2: This figure displays how the lift force varies with the mass of the pig.

To calculate the acceleration upwards, the difference between F_l and F_w is divided by the mass of pig

$$a = \frac{F_l - F_w}{M_{pig}}. \quad (3)$$

Assuming the pig starts the ascent at rest, the time taken for the pig to reach an altitude equal to the top of Battersea Power Station is found with the rearranged SUVAT equation for displacement

$$t = \sqrt{\frac{2S}{a}}. \quad (4)$$

Here S is the height of Battersea Power Station (101 m) and a is the acceleration from Equation (3). For simplicity, we assume that the hang glider has a small propeller, with negligible mass, that matches the wind speed so the pig stays stationary with respect to the horizontal as it rises.

Results

Further to Figure 1, we plotted the relative wind velocity against the mass of the pig as shown in Figure 2. This illustrates the wind velocity required to successfully counter the force of gravity on the pig, as shown by the parabolic curve. We have taken into account the mass of the glider (22 kg), however the mass axis of the graph represents the mass of the pig being lifted with the additional glider mass set to zero for the axis. For this example, we choose a pig's mass of 70 kg, which is within the range of typical pig masses [1].

From Figure 2, we determine the wind velocity needed to lift a pig of mass 70 kg is 20.4 ms^{-1}. However, for there to be a positive upwards acceleration we use a wind velocity of 24 ms^{-1}, equivalent to a severe gale as defined by The Met Office [5]. Using Equation (3), the acceleration of the pig was found to be 3.8 ms^{-2}; with F_l and F_w taken to be 955 N and 687 N, respectively.

Therefore, by substituting the acceleration into Equation (4), the time taken for the pig to reach the height of Battersea Power Station is $t = 7.3$ s.

Conclusion

For a typical pig mass of 70 kg, attached to the Falcon 4 hang glider, the minumum wind velocity required for the pig to fly, is 20.4 ms^{-1}. Furthermore, in order to fly at 101 m, allowing flight over Battersea Power Station, we conclude a wind velocity of 24 ms^{-1} is required. We have found the time taken to reach this height to be 7.3 s, based on an acceleration of 3.8 ms^{-2}. Without the considerable lift provided by a hang glider's large aerofoil surface, it would be considerably more difficult for a pig to fly, as may be seen in nature.

From our results, we have shown that it is possible for a pig of mass 70 kg to fly when the velocity of the wind exceeds 20.4 ms^{-1}, although the authors recommend against allowing pigs to fly for their own safety.

References

[1] `https://goo.gl/Esf3S5` [Accessed 26/10/16]

[2] `https://goo.gl/YNheE7` [Accessed 26/10/16]

[3] `https://goo.gl/Ebt6dJ` [Accessed 26/10/16]

[4] `https://goo.gl/8Z9wTP` [Accessed 26/10/16]

[5] `https://goo.gl/MBkOH1` [Accessed 26/10/16]