A Recreation of The Wings of Daedalus

Arnav Malhotra

January 2026

1 Introduction

The story "Daedalus and Icarus" by Ovid is one of the earliest stories featuring a piece of technology not working as intended, causing tragedy. The premise of the story is that an engineer, Daedalus, detests his exile on the island of Crete, and decides to escape it. He knew that King Minos, the King of Crete, controlled the land and sea, blocking any escapes through them. He realized that the only way out was by the air, through flight. He then created two pairs of wings to be used for the escape. His son, also imprisoned on the island with Daedalus, was then warned by his father to fly in the middle zone: not too low, where the water would add too much weight to the wings, and not too high, where the sun would burn the wings.

However, as the flight began, Icarus became too enthusiastic about his new method of transportation, and ended up flying too close to the sun, causing the wings to burn and Icarus to fall to his death. With this project, a design for the true wings of Daedalus will be created through the laws of aerodynamics, optimized to fly just as in the myth.

2 Assumptions

Before making calculations, the core assumptions must be established:

- Total Mass (m): 65 kg (50 kg human + 15 kg structure)
- Force of Weight (W): $W = mg = (65)(9.81) = 637.65$ N. By Newton's second law, $f = ma$, force is equal to the product of mass and acceleration. The acceleration of gravity on Earth is $9.81 m/s^2$ and the mass stated above is 65 kg, meaning that the total weight (force of gravity) is 637.65 Newtons.
- Air Density: 1.225 kg/m^3. Air density is measured as the mass of air per cubic meter, and is 1.225 kg/m^3 at sea level. This perfectly aligns with the middle zone constraint given by Daedalus, as air density can change with altitude, highlighting the need to stay within a certain height for the parameters of the wings to be optimal.

- Running Speed (takeoff speed): 12.5 m/s. This is approximately the speed of Usain Bolt in his world record $100m$.
- The person operating the wings is wearing an exoskeleton in their arms allowing them to expend unlimited power.

3 Wing Geometry

3.1 Wing Area

To calculate the total area of each wing, the Lift Equation will be used. The Lift Equation quantifies the relationship between the force of lift, air density, velocity, coefficient of lift, and wing area:

$$L = \frac{1}{2}\rho v^2 S C_L \tag{1}$$

Where:

- L is the force of lift, the force pushing the person up. We want the force of lift to be equal to the force of weight, $W = 637.65N$, so that the person neither goes up nor down, staying in the middle zone.
- ρ is the air density.
- v is the velocity.
- S is the area of the wing.
- C_L is the Coefficient of Lift, a number quantifying how well a wing generates lift. Most birds have a C_L of around 1.5.

Through algebraic rearranging of this equation, the optimal area of the wing is $S = \frac{2L}{\rho v^2 C_L} = \frac{(2)(637.65)}{(1.225)(12.5^2)(1.5)} = 4.44\ \text{m}^2$.

3.2 Aspect Ratio

Wings with a higher aspect ratio (AR) will have a longer length relative to width, and will be less maneuverable but with a greater range.

Wings with too high of an AR will break apart, however, and wings with a lower AR will have too much induced drag. Most wings made for this kind of long distance flight over the sea, such as those of albatrosses, have an AR between 15 and 20, so the target will be $AR = 18$. The aspect ratio equation says:

$$AR = \frac{b^2}{S} \tag{2}$$

Where b is the wingspan. From this, b is calculated as: $b = \sqrt{S \cdot AR} = \sqrt{4.44 \cdot 18} = 8.94$ m.

The mean aerodynamic chord (the average distance between the back edge and front edge of the wing) is then calculated simply as the area divided by the wingspan, or $c = \frac{S}{b} = \frac{4.44}{8.94} = 0.50$ m.

4 Ornithopter Dynamics

An ornithopter is an aircraft that flies by flapping wings, exactly like in the myth. Because of this, the frequency of flaps must be calculated. First, the length of each flap, or amplitude, is calculated:

$$A = l \sin(30^\circ) = 4.22 \sin(30^\circ) = 2.11 \text{ m} \tag{3}$$

Where l is the length of one wing, calculated as $\frac{8.94-0.5}{2} = 4.22$ (accounting for a person with a width of 0.5 m), and the maximum angle at which the wing flaps is 30°, mimicking albatrosses.

Now that the length of each flap is retrieved, the frequency of each flap can now be calculated using the formula for the Strouhal Number (St), which governs the efficiency of flapping:

$$St = \frac{fA}{v} \tag{4}$$

Where f is the frequency in hertz (Hz), or amount of flaps per second. A common St for albatrosses is 0.25, so $f = \frac{StU}{A} = \frac{(0.25)(12.5)}{2.11} = 1.48$ Hz, therefore the operator should flap their wings about 3 times every 2 seconds.

5 Airfoil Physics and Reynolds Number

Lift is generated as air flows around a wing, and it must be made sure that the air sticks to the wing and does not generate a "dead spot" without any airflow. This is predicted by the Reynolds Number (Re):

$$Re = \frac{\rho v c}{\mu} \tag{5}$$

Where μ is the dynamic viscosity of air, or the air's internal resistance to flow, equal to about $1.8 \cdot 10^{-5} \frac{\text{kg}}{\text{m}\cdot\text{s}}$. Therefore, $Re = \frac{(1.225)(12.5)(0.5)}{0.000018} = 425,347$. A good spot for Re for an aircraft of this size would be higher than this. To combat this risk of "dead spots," the aircraft must feature feathers on it, decreasing the smoothness of the flow and the risk of pockets without any flow.

6 Drag and Power

There are two kinds of drag:

- Parasitic Drag (C_p): the air resistance hitting the operator's body, the feathers, and other friction.

- Induced Drag ($C_{D,i}$): drag penalty for generating lift.

A cyclist has a C_p of about 0.2, so it will be assumed that Daedalus and Icarus face that same amount of drag. The calculation for $C_{D,i}$ is:

$$C_{D,i} = \frac{C_L^2}{\pi \cdot AR \cdot e} \tag{6}$$

Where e is the span efficiency factor, which measures how closely a wing's lift distribution matches the ideal, minimum induced drag distribution. It will be chosen as 0.8. Therefore, $C_{D,i} = \frac{1.5^2}{\pi 180.8} = 0.05$.

Therefore, the total drag coefficient is $C_d = 0.2 + 0.05 = 0.25$. The Drag Force, the actual force pushing against the aircraft due to drag, is then calculated using the drag equation:

$$F_d = \frac{1}{2}\rho v^2 C_d S \tag{7}$$

This is then calculated as $F_d = \frac{1}{2} \cdot 1.225 \cdot 12.5^2 \cdot 0.25 \cdot 4.44 = 106.23$ N.

We can then use this to calculate an actual power expenditure necessary for flight, in order to combat drag:

$$P = F_d \cdot v \tag{8}$$

Therefore, the power expenditure needed to sustain flight with the wings is $P = 106.23 \cdot 12.5 = 1327.88$ W. This wattage is very unsustainable for the average human with just their arms, which can only expend about 100 W for a sustained period of time. This explains the necessity of an exoskeleton capable of increasing the power of the human thirteenfold.

7 Conclusion

This re imagining of the wings in the story of Icarus and Daedalus provides a real-world demonstration of how they could have actually existed. To summarize the optimized parameters for the wings found:

Assumptions:

- Total Mass: 65 kg
- Air Density: 1.225 kg/m^3
- Speed: 12.5 m/s
- $C_L = 1.5$
- $AR = 18$
- The maximum angle of the flaps is 30°

Found Parameters:

- The total area of both wings is 4.44 m^2
- The wingspan is 8.94 m
- The mean aerodynamic chord is 0.5 m
- The wings flap about 3 times every 2 seconds
- There are feathers on the wings, to act as turbulators
- The exoskeleton (or mythological equivalent) combined with the human generates around 1327.88 W of power