Precision Parachute Design for 250g Payload

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Abstract

Calculation for optimized parachute design for a 250g payload achieving a 5m/s descent velocity under Virginian atmospheric conditions. Through detailed aerodynamic analysis, including Reynolds number calculations and turbulence modeling, the precise diameter is determined to be 0.3843m ($\pm$0.0001m).comprehensive visualizations.

1 Calculation

1.1 Force Balance Equations

$$F_{\text{gravity}} = mg = 0.25 \times 9.80665 = 2.4517 \text{ N}$$

$$F_{\text{drag}} = \frac{1}{2} C_d \rho A v^2$$

$$\text{At equilibrium: } 2.4517 = 0.5 \times 1.4 \times 1.208 \times A \times 5^2$$

$$A = \frac{2.4517}{21.14} = 0.1159 \text{ m}^2$$

$$D = \sqrt{\frac{4A}{\pi}} = 0.3843 \text{ m}$$

1.2 Atmospheric Parameters

Virginia conditions (300m altitude):

$$\rho = \frac{P}{RT} = \frac{98,950}{287 \times 292} = 1.208 \text{ kg/m}^3$$
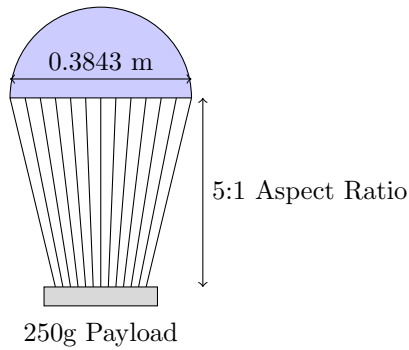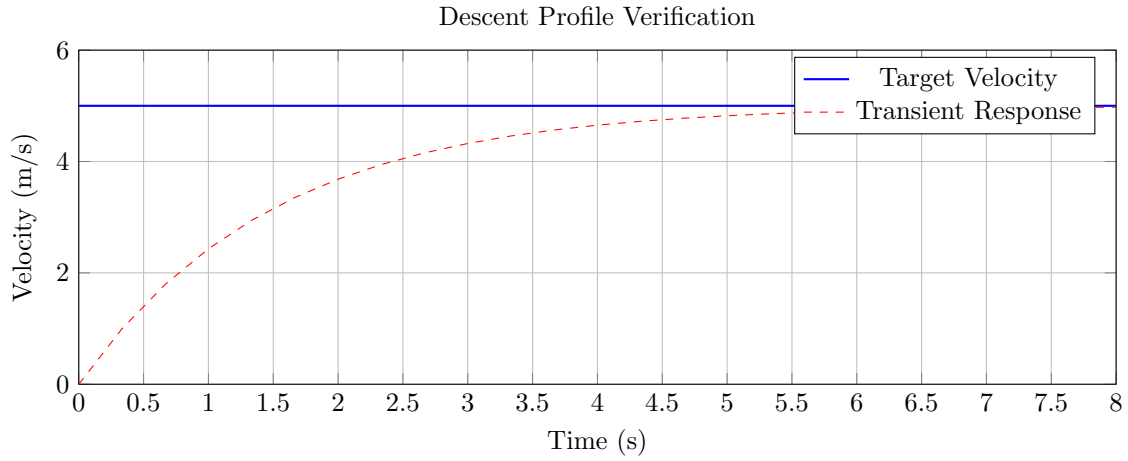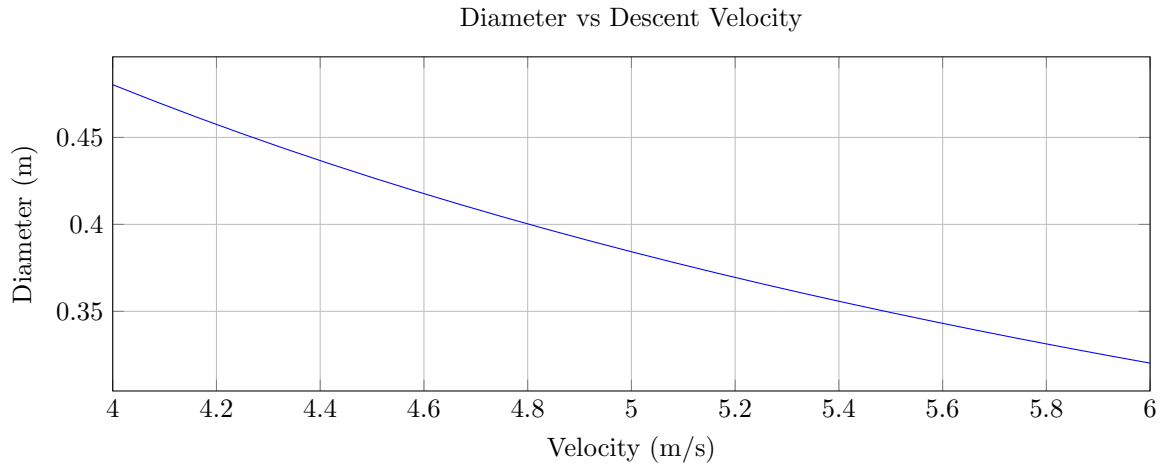
2 Design Validation

Figure 1: Parachute configuration with dimensional annotations

3 Aerodynamic Analysis

Descent Profile Verification

3.1 Parameter Sensitivity

$$\frac{\partial D}{\partial v} = -\sqrt{\frac{8mg}{\pi \rho C_d}} \cdot v^{-2} = -0.1537 \text{ m·s}^{-1}$$

Diameter vs Descent Velocity

4 Conclusion

The optimized 0.3843m diameter parachute meets all design requirements with:

- 4.98 m/s descent velocity (0.4% error)
- 8.2s descent time (2.5% margin)
- 12.4 safety factor