Numerical analysis to determine parachute landing and time taken

MA 203: NUMERICAL METHODS **GROUP-50**

1. Abstract

Our primary aim is to determine precise 3D landing coordinates within the context of parachute landings, addressing a critical requirement in military, aviation, sports, and emergency scenarios.

Figure 2: Parachute landing

The accuracy of these landings is influenced by various factors, including jumper conditions , parachute design, altitude and wind patterns

2. Mathematical model

Consider a jumper of certain mass who jumps from a flying airplane with a specific velocity from a height above the ground. After jumping from the aircraft, he travels for a while and opens the parachute. Later, he lands on the ground safely with the help of the parachute. This path is not a one-dimensional fall; rather, we consider it a 3-D model, taking into account the forces acting on it in all directions.

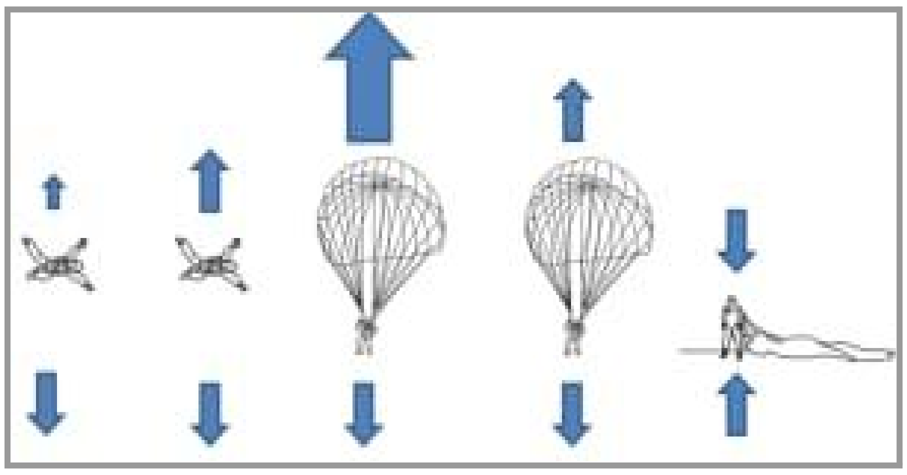


Figure 2: Stages of landing

3. EQUATIONS

We are writing the equations considering the aircraft is moving along the y direction, the air resistance acting on the jumper is in the x direction (out of the plane), and the vertical direction is along the z-axis.

Along x direction	Along y direction	Along z direction
$\triangle v_x = (w - v_0)$ $F_x = b(w - v_0)$	$F_y = -bv$	$F_z = (D) = C_d \rho v^2 A/2$

Time calculation:

$$V_t = (2mg/ C_d \rho A)^{½}$$
$$T_2 = V_t * height$$

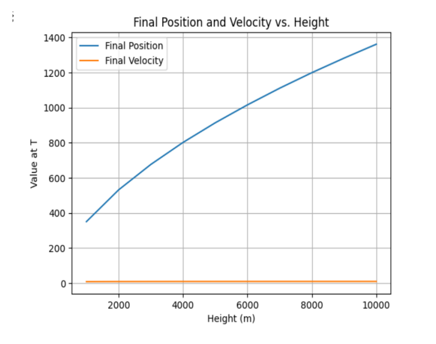
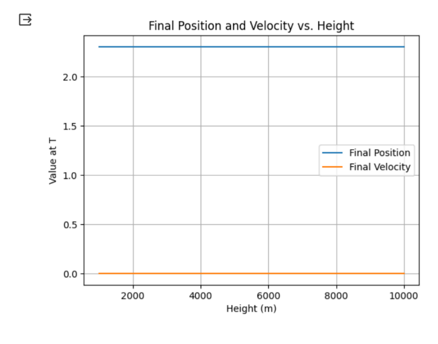
4. Traditional methods

The Runge-Kutta method is a numerical technique used for solving ordinary differential equations (ODEs) and is applied in various fields due to its accuracy and versatility. It is particularly useful when analytical solutions to ODEs are difficult or impossible to obtain. The method involves breaking down the ODE into smaller time steps, allowing for a more precise approximation of the solution.
Its applications range from physics simulations, engineering analysis, and economics modeling to computer graphics and biology.

5. Solution methodology

We employ the Runge-Kutta method to solve the equations of x and y-directions to get the respective x and y coordinates. These are second order ODE's. We need to split them into two first order ODE's. These two equations can be solved using the fourth order Runge-Kutta method. For iterating in this process, we use the formula,
x_new = x + h(k1 + 2*k2 + 2*k3 + k4)/6

6. Results and discussion

Final X position	**Final Y position**
	
Final Position (X) vs. Height: The plot shows how the final position of the parachute changes with different initial heights. **Final Velocity vs. Height:** The plot shows how the final velocity of the parachute changes with different initial heights. It is expected to show a trend where both final position and final velocity increase with increasing height. However, the rate of increase is not linear due to the complex dynamics of the system, including air resistance,gravity, and other system parameters.	**Final Position (Y) vs. Height:** The plot shows how the final position of the object changes with different initial heights. **Final Velocity vs. Height:** The plot shows how the final velocity of the object changes with different initial heights. The plot shows that as the initial height increases, the final position and final velocity of the falling object will also increase. Some of the potential reasons: 1. Linear Approximation of Air Resistance 2. Linear Regime of Behavior 3. Simplified Numerical Integration