Projectile Trajectory with Air Drag

Range, maximum height, flight time and impact speed of a projectile with quadratic air drag, by numerical integration, compared with the drag-free range.

Method: Point-mass trajectory with quadratic drag

Input parameters

Unit system: SI

Parameter	Value	Unit
Launch speed	40.000	m/s
Launch angle	40.000	°
Mass	0.14500	kg
Diameter (frontal area πd²/4)	73.000	mm
Drag coefficient (sphere 0.3–0.5)	0.35000	
Air density	1.2000	kg/m³
Launch height above the landing level	1.5000	m

Calculated results

Parameter	Value	Unit
Range	98.340	m
Maximum height above the landing level	26.653	m
Flight time	4.5863	s
Impact speed	25.519	m/s
Impact angle below horizontal	53.139	°
Range without drag	162.44	m

Notes for this case

- Point mass with quadratic drag F = ½ρC_D A v², integrated by fourth-order Runge–Kutta to the landing level. Spin (Magnus lift), wind and changes of C_D with speed are ignored.

Formula and method

$$\frac{d\mathbf{v}}{dt} = -g\hat{\mathbf{y}} - \frac{\rho C_D A}{2m}|\mathbf{v}|\mathbf{v}, \quad A = \frac{\pi d^2}{4}$$

Variables

v_0	Launch speed	m/s
θ	Launch angle	rad
m	Mass	kg
d	Diameter (frontal area πd²/4)	m
C_D	Drag coefficient (sphere 0.3–0.5)	-
ρ	Air density	kg/m³
h_0	Launch height above the landing level	m
R	Range	m
h_{max}	Maximum height above the landing level	m
t_f	Flight time	s
v_i	Impact speed	m/s

θ_i	Impact angle below horizontal	rad
R_{vac}	Range without drag	m

Method and standards

Projectile dynamics with drag.

Assumptions and limits

- Point mass, constant density and C_D, no wind or spin.

References

Point-mass trajectory with quadratic drag

Report details

Report reference	FCC-6HT7-PKVQ (the same inputs always give the same reference)
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Software release	FireCAD Calc, release of 22 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/statics-dynamics/projectile-with-drag

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.