Projectile Motion: Range, Maximum Height and Time of Flight

Range, maximum height, time of flight and impact velocity of a projectile launched at a speed and angle from a height, without air resistance.

Method: Meriam and Kraige; Engineering Mechanics: Dynamics; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Launch speed	20.000	m/s
Launch angle above horizontal	45.000	°
Launch height above landing level	0	m

Calculated results

Parameter	Value	Unit
Time of flight	2.8842	s
Horizontal range	40.789	m
Maximum height above launch	10.197	m
Impact speed	20.000	m/s
Impact angle below horizontal	45.000	°

Notes for this case

- No air drag; real ranges are shorter, much shorter for light or fast objects.

Formula and method

$$t_f = \frac{v_0 \sin\theta + \sqrt{v_0^2 \sin^2\theta + 2gh_0}}{g}, \quad R = v_0 \cos\theta \, t_f, \quad h_{max} = \frac{v_0^2 \sin^2\theta}{2g}$$

Variables

v_0	Launch speed	m/s
θ	Launch angle above horizontal	rad
h_0	Launch height above landing level	m
t_f	Time of flight	s
R	Horizontal range	m
h_{max}	Maximum height above launch	m
v_i	Impact speed	m/s
θ_i	Impact angle below horizontal	rad

Method and standards

Kinematics under constant gravity.

Assumptions and limits

- Flat earth; no drag.

References

- Meriam and Kraige
- Engineering Mechanics: Dynamics
- 8th ed. (Wiley, 2015)
- ch. 2 (projectile motion)

Report details

Report reference	FCC-KSJ5-72EH (the same inputs always give the same reference)
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Release checks	2 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-motion

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.