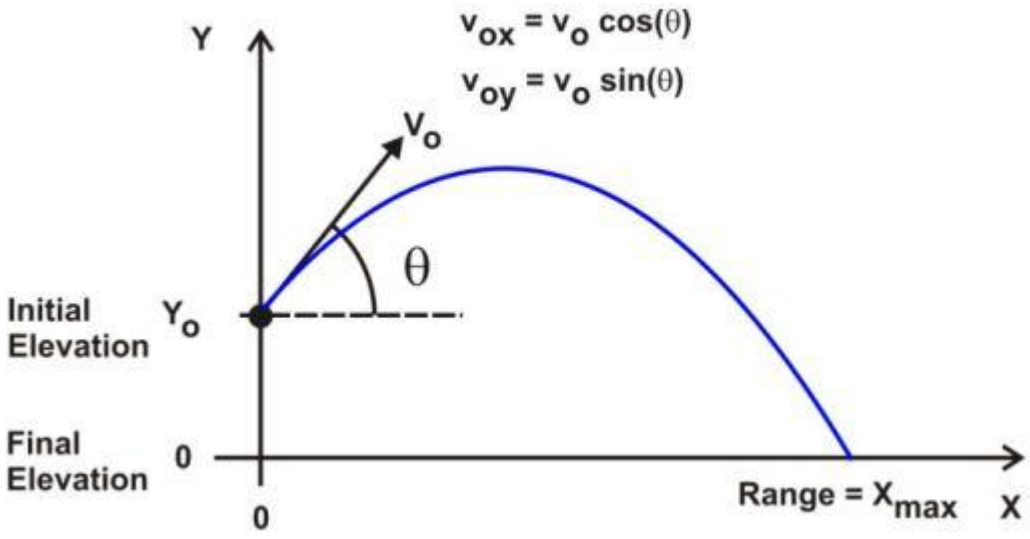
Question #54207, Physics / Mechanics | Kinematics | Dynamics

How a missile can fly kilometers without wings
Is Often trajectory of 45 degree from the launching surface is applied in every missile.

Answer:

According to kinematic the bullet trajectory in airless space described by simple equations:



For speed:

$$v_x(t) = v_0 \cos(\theta)$$

$$v_y(t) = -gt + v_0 \sin(\theta)$$

For coordinates:

$$x(t) = v_0 \cos(\theta) \cdot t$$

$$y(t) = -\frac{1}{2} g t^2 + v_0 \sin(\theta) \cdot t + Y_o$$

http://www.southalabama.edu/physics/lectures/boleman/projectile_motion.html

The range given by:

$$X_{max} = (v_o \sin(\theta) + \sqrt{(v_o \sin(\theta))^2 + 2gY_o}) \frac{v_o}{g} \cos(\theta)$$

g defined from here https://en.wikipedia.org/wiki/Gravitational_acceleration

For https://en.wikipedia.org/wiki/Starstreak_(missile) speed is about v_o =1000 m/s, will take $Y_o = 0$ and $\theta = 45°$:

$$X_{max} = \left(v_o \sin(\theta) + \sqrt{(v_o \sin(\theta))^2 + 2gY_o}\right)\frac{v_o}{g}\cos(\theta) \sim 10^5 m = 100\ km$$

In the fact that air act to the projectile as drag or resistance force it range will decrease (in some cases by order)

So the projectile may fly huge range just by inertia.

According to the given before formula 45 degree is the optimum for case of $Y_o = 0$ and airless (drugless environment) projectile movement :

$$X_{max} = \left(v_o \sin(\theta) + \sqrt{(v_o \sin(\theta))^2 + 2gY_o}\right)\frac{v_o}{g}\cos(\theta) = \frac{{v_o}^2}{g}2\sin(\theta)\cos(\theta) = \frac{{v_o}^2}{g}\sin(2\theta)$$
$$\rightarrow optimum: \theta = 45°, cause\ \sin(2\theta) = 1\ is\ maximum$$

But for cases of real motion in the air where drug is present the optimal angle may vary in big interval in both from $\theta = 45°$ side.