Q- A ball is thrown at 20 m/s at an angle of 30^0 to the horizontal. It is thrown in the direction of a wall which is 5m away on the ground, and 2m high. Does the ball go over the wall, or does it collide with the wall?

A vector has no effect in its perpendicular direction hence we resolve a vector in mutually perpendicular directions. In projectile motion the only force is the gravity and hence the acceleration of a particle is only due to gravity which is vertically downwards.

Resolving the velocity of projection of the particle in horizontal and vertical directions we can solve the motion separately in horizontal and vertical direction and time will be a parameter common to both motions.

Let the velocity of projection be u at angle α to the horizontal.
The horizontal component of this velocity will be u*cos α.

As there is no horizontal force or acceleration it will move horizontally with a constant speed u cosα and hence the horizontal distance as a function of time will be

X = u cosα *t --------- (1)

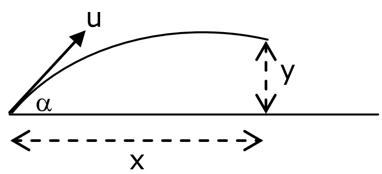
Now the vertical component of the initial velocity will be u*sin α and the acceleration is -g, hence vertical displacement in time t is given by the second equation of motion

[s = u*t + ½ at^2] as

y = u*sin α*t + ½ (-g) t^2

Substituting the value of t from equation (1) we get

$$y = u\sin\alpha\left(\frac{x}{u\cos\alpha}\right) - \frac{gx^2}{2u^2\cos^2\alpha}$$



Or $$y = x\tan\alpha - \frac{gx^2}{2u^2\cos^2\alpha}$$

This is the relation between x and y coordinates of the path of the projectile and called equation of trajectory.

Substituting the values to find the height of the projectile at distance x from the point of projection we have

$$y = 5.0\tan 30^0 - \frac{9.8*5.0^2}{2*20^2\cos^2 30^0}$$

Or $$y = 5.0*0.577 - \frac{9.8*25}{800*0.75} = 2.885 - 0.408 = 2.477\,\text{m}$$

As y = 2.477 m is greater than the height 2.0 m of the wall the ball will go over the wall.