

Projectile Motion

During the flight phase, an object is under the influence of gravity and air resistance. This presents an interesting situation to study: Projectile Motion. Consider all the activities in which the object being projected is a person: long jump, high jump, diving, gymnastics, are a few examples. Of course there are a lot of sports which involve throwing some object: baseball, football, softball, basketball and so forth.

We will study projectile motion in order to understand the relationship between force and acceleration. To start with, we will ignore the effects of air resistance on projectile motion to simplify the problem. However, we should realize that air resistance is a force and is calculated as $F = \frac{1}{2}\rho v^2 C_d A$, indicating that the force due to air resistance is a function of velocity of the object relative to the flow of air over the object and some other constants ($\frac{1}{2}\rho C_d A$). The constants are:

ρ : density of air

C_d : drag coefficient ('smoothness' of the object)

A: frontal area of the object moving through the air

This is the same equation as 'drag' force of an object moving through any fluid (e.g., air, water). For our initial discussion of projectile motion, we can ignore the air resistance force as it will be very small. However, as we will see, eventually we cannot ignore air resistance (and we should not) when we are discussing actual projectile flight path of projectiles. For example, a baseball hit against the wind, a pitcher throwing a curveball, a place kicker kicking a field goal in the wind. These are all examples of where the force of air acting on the object influence the object's motion.

What happens when a ball is dropped from the fifth floor of a building? Of course the ball will move towards the ground, no magic there. But how will it move? Constant velocity? Constant acceleration? To answer this question, you have to identify the forces acting on the ball – because **forces cause a change in motion**.

Considering that the ball is a projectile, only gravity and air resistance act on the ball – and we will ignore the effects of air resistance presently. So, only one force is acting on the ball! Remembering that $\sum F = ma$, then we should be able to see that the ball will undergo an acceleration due to the force applied to it. It just so happens that the *force due to gravity* makes all objects accelerate at -9.8 m/s^2 .

So, we have one force acting on a projectile causing it to accelerate at -9.8 m/s^2 . Now we should be able to understand the change in motion due to this one force. Furthermore, we should be able to predict how the motion is going to change given that only the force of gravity acts on the projectile.

As we continue through projectile motion, you should often remind yourself that we are covering this concept in order to understand the effect of a force on changing motion. Can you draw the vertical PVA of a projectile? How about the horizontal PVA (considering gravity is the only force acting on the object)?