PROJECTILE MOTION

Parameters of projectile motion

To discover various aspects of projectile motion, we can utilize differential equations of motion

(1) $v = u - gt$

(2) $s = ut - \frac{1}{2}gt^2$

(3) $v^2 = u^2 - 2gs$

Where

u = Initial velocity

g = Acceleration due to gravity

t = Time

s = Displacement

v = Final velocity

Total Time of Flight

Resultant displacement (s) = 0 in Vertical direction. Therefore, the time of flight formula is given by using the Equation of motion:

$gt^2 = 2(uyt - sy)$ [Here, $uy = u \sin \theta$ and $sy = 0$]

$gt^2 = 2t \times u \sin \theta$

Therefore, the time-of-flight formula (t) is given by:

Total Time of Flight $(t) = \frac{2u\sin\theta}{g}$

Horizontal Range

Horizontal Range (OA) = Horizontal component of velocity (ux) × Total Flight Time (t)

$$R = u\cos(\theta) \times \frac{2u\sin(\theta)}{g}$$

Therefore, in a projectile motion, the Horizontal Range is given by (R):

Horizontal Range $(R) = \frac{u^2 \sin 2\theta}{g}$

Maximum range landing speed

The maximum range landing speed, often referred to as the optimal landing speed, is the speed at which an aircraft should ideally touch down on the runway to achieve the longest possible distance traveled while landing. This speed is determined by a variety of factors, including the aircraft's weight, wind conditions, runway length, and aircraft performance characteristics.

To calculate the maximum range landing speed, pilots and flight planners typically consider the aircraft's performance charts provided by the manufacturer. These charts take into account the aircraft's specific configuration, such as flap settings and landing gear position, along with the prevailing atmospheric conditions.

In general, the maximum range landing speed is slightly above the aircraft's stall speed in landing configuration. The stall speed varies depending on factors such as weight and configuration, but it is the lowest speed at which the aircraft can maintain controlled flight.

During the landing phase, aircraft aim to touch down at or slightly above this optimal speed to ensure the most efficient use of runway length while maintaining safe control of the aircraft. Touching down at too high a speed can result in excessive braking and potentially overrun the runway, while touching down too slowly can lead to a harder landing and potential loss of control.

Overall, the maximum range landing speed is a critical parameter in aircraft operations, ensuring a balance between efficiency and safety during the landing phase. Pilots rely on careful calculations and experience to determine the appropriate landing speed for each specific landing scenario.

Symmetry of the projectile motion

Projectile motion refers to the motion of an object that is projected into the air and then moves under the influence of gravity. The symmetry of projectile motion typically refers to the fact that the path followed by the projectile is symmetrical with respect to its highest point.

Here's how the symmetry manifests

Vertical Motion: At the highest point of the projectile's trajectory, its vertical velocity becomes momentarily zero before it starts descending. This means that the time taken to reach the highest point is equal to the time taken to descend from the highest point to the same height on the other side. This symmetry ensures that the time of flight upward is equal to the time of flight downward.

Horizontal Motion: Assuming negligible air resistance, the horizontal component of the projectile's velocity remains constant throughout its motion. Therefore, the time taken to travel a certain horizontal distance on the way up is the same as the time taken to travel the same horizontal distance on the way down. This symmetry ensures that the horizontal displacement is the same before and after reaching the highest point.

This symmetry makes analyzing projectile motion relatively straightforward, as it allows us to split the motion into two symmetrical halves: upward motion and downward motion. This simplifies calculations and allows for a clearer understanding of the motion's characteristics.