Science behind Neeraj's success

Distance covered by javelin - 21.4 m
Travel time – 2.2 sec
Wind speed – +2.35 m/s
Air direction – positive
Release Angle – 48

$$T = \frac{2U \sin \theta}{g} \quad \text{①}$$

$$2.2 = \frac{2u \sin 48}{9.8}$$

$$9.8 \times 2.2 = 2U \sin(48°)$$

$$\frac{21.56}{2} = U^* \quad 0.73$$

$$\frac{10.78}{0.73} = U$$

$$14.76 = U_x \longrightarrow \text{horizontal Velocity}$$

$$\sin \theta = \frac{10.78}{U}$$

$$R = \frac{u^2 \sin}{g}$$

$$21.4 = \frac{u^2 \sin}{9.8}$$

$$209.72 =$$

$$\frac{209.72}{211.99} =$$

$$21.4 = \frac{u^2 \sin 2\theta}{9.8}$$

$$209.72 = u^2 \sin 2\theta \quad \text{———} \quad \text{(II)}$$

$$\sin 2\theta = 2\sin\theta\cos\theta \qquad)$$

$$209.72 = 2u^2 \sin\theta \cos\theta$$

$$209.72 = 2u^2 * \frac{10.78}{u} \cos\theta$$

$$u\cos\theta = 9.8 \text{ m/s} \quad \text{———} \quad \text{(III)}$$

$$u = \frac{9.8}{\cos 48} \qquad [\therefore \theta = 48]$$

$$u = \frac{9.8}{0.64} = 15.31 \text{ m/s}$$

For 45°

$$u = \frac{9.8}{0.52} = 18.84 \text{ m/s}$$

For 36°

$$u = \frac{9.8}{36g} = \text{(circled out)}$$

$$= \frac{9.8}{0.809} = 20.11 \text{ m/s}$$

Analyze how changing the release angle affects the range.

The release angle is an important factor that affects the range of a projectile. The range is the horizontal distance traveled by a projectile (such as a ball, projectile, or rocket) before it hits the ground. To understand how changing the release angle affects the range, we can consider the following key principles:

The Ideal Launch Angle: The ideal launch angle for achieving the maximum range depends on the initial velocity and the acceleration due to gravity. In the absence of air resistance, the ideal launch angle for maximum range is 45 degrees. This is because at this angle, the projectile spends an equal amount of time in the vertical and horizontal motion, resulting in the greatest horizontal displacement.

Launch Angle Less Than 45 Degrees: When the launch angle is less than 45 degrees, the projectile spends more time in horizontal motion and less time in vertical motion. As a result, it covers less horizontal distance before hitting the ground. The range decreases as the launch angle decreases from 45 degrees.

Launch Angle Greater Than 45 Degrees: When the launch angle is greater than 45 degrees, the projectile spends more time in vertical motion and less time in horizontal motion. Again, this leads to less horizontal distance covered before impact. So, the range also decreases as the launch angle increases beyond 45 degrees.

Special Cases: There are two special cases to consider:

Launch Angle of 0 Degrees: If the projectile is launched at a 0-degree angle (horizontally), it will have maximum vertical displacement (height) but zero horizontal displacement. In this case, the range is zero.

Launch Angle of 90 Degrees: If the projectile is launched at a 90-degree angle (vertically), it will have maximum horizontal displacement but zero vertical displacement. Again, the range is zero.
Impact of Air Resistance: In real-world scenarios with air resistance, the ideal launch angle for maximum range is less than 45 degrees, typically around 35-40 degrees, depending on the specific conditions. This is because air resistance affects the trajectory, and a lower launch angle helps reduce the impact of air resistance, increasing the range compared to a 45-degree launch angle.

In summary, changing the release angle affects the range of a projectile by altering the balance between vertical and horizontal motion. The ideal launch angle for maximum range depends on factors such as initial velocity and air resistance. In most practical situations, it's less than 45 degrees, and deviations from this angle result in reduced range. The specific ideal angle can be calculated using mathematical formulas that take into account these factors.

role of air speed, launch angle, and release velocity in achieving maximum distance.

To achieve maximum distance (range) for a projectile, several factors come into play, including airspeed, launch angle, and release velocity. These factors interact in complex ways, and understanding their roles is crucial for optimizing the projectile's range. Here's a breakdown of their roles:

Air Speed (Air Resistance):

Role: Air speed, or more accurately, air resistance (also known as drag), plays a significant role in determining the range of a projectile. Air resistance opposes the motion of the projectile, reducing its speed and altering its trajectory.
Effect: Higher airspeed (faster-moving air) increases air resistance, which can significantly reduce the range of the projectile. The faster the projectile moves, the greater the impact of air resistance. Therefore, minimizing air resistance is crucial for achieving maximum distance.
Optimization: To mitigate the effects of air resistance and maximize range, you want to minimize the time the projectile spends in the air. This often involves selecting an optimal launch angle and release velocity that balances vertical and horizontal motion, as explained below.
Launch Angle:

Role: The launch angle is the angle at which the projectile is launched relative to the horizontal plane. It plays a critical role in determining the projectile's range.
Effect: The ideal launch angle for maximum range depends on the presence of air resistance. In the absence of air resistance, the ideal launch angle is 45 degrees, as it balances vertical and horizontal motion. However, with air resistance, the ideal angle is typically less than 45 degrees.
Optimization: To maximize range in the presence of air resistance, you should choose a launch angle that minimizes the impact of air resistance. This often means launching the projectile at an angle lower than 45 degrees.
Release Velocity (Initial Velocity):

Role: The release velocity, or initial velocity, is the speed at which the projectile is launched. It's a crucial factor in determining both the height and horizontal distance the projectile can achieve.
Effect: A higher release velocity leads to greater initial speed, which translates into a longer horizontal range, assuming all other factors remain constant.
Optimization: To maximize range, you should aim for the highest practical release velocity within the constraints of your system (e.g., the strength of the launch mechanism). However, it's important to note that extremely high velocities may lead to increased air resistance, so there's a trade-off to consider.

In summary, achieving maximum distance for a projectile involves optimizing the interplay of air speed (air resistance), launch angle, and release velocity. To do this effectively, you need to strike a balance between vertical and horizontal motion and minimize the impact of air resistance. This may involve launching the projectile at an angle less than 45 degrees and using the highest practical release velocity while considering the effects of air resistance. Calculations and simulations can help determine the optimal combination of these factors for a specific scenario.

applications of projectile motion in sports and engineering.

Projectile motion has several practical applications in both sports and engineering. Here are some examples:

Sports:

Projectile Trajectory in Ball Sports: In sports like baseball, softball, golf, and cricket, understanding projectile motion is crucial for players, coaches, and engineers who design equipment. Players need to predict the trajectory of a ball to make accurate catches, throws, and shots. Engineers design equipment, such as golf clubs and baseball bats, to optimize the launch angle and velocity for maximum distance and accuracy.

Basketball Shooting: Basketball players use projectile motion principles to determine the angle and force needed to make a successful shot, especially for three-pointers and long-range shots.

Archery: Archers use projectile motion principles to calculate the trajectory of arrows. They need to understand the angle, force, and distance to hit a target accurately.

Football Kicking and Passing: In American football, soccer, and rugby, players must calculate the trajectory of the ball when kicking or passing to their teammates. This involves considering launch angles and velocities for the desired outcome.

Tennis and Table Tennis: Racket sports like tennis and table tennis rely on understanding the trajectory of the ball to make accurate shots, especially for serves and smashes.

Engineering:

Projectile Launchers: Engineers use principles of projectile motion to design and optimize the performance of various launchers and cannons, such as water cannons, air cannons, and even space launch vehicles. Calculations involving launch angle, initial velocity, and trajectory are essential in this context.

Ballistics: In military and law enforcement, the study of projectile motion is vital for ballistics, which involves the analysis of the flight paths of bullets and projectiles fired from firearms. Engineers and scientists develop weapons and ammunition with specific performance characteristics, taking into account range, accuracy, and stopping power.

Aerospace Engineering: In the field of aerospace engineering, the principles of projectile motion are applied to spacecraft and satellite trajectories. Engineers calculate and adjust launch angles and velocities to achieve specific orbits or interplanetary trajectories.

Projectiles in Civil Engineering: Civil engineers use projectile motion principles when designing systems involving the launching of objects or materials, such as concrete pumps, water jets, or pneumatic systems for construction or cleaning purposes.

Sports Equipment Design: Engineers designing sports equipment, such as golf clubs, tennis rackets, and baseball bats, utilize projectile motion principles to optimize the performance characteristics of these products.

Automotive Testing: In automotive engineering, the principles of projectile motion are used in vehicle crash testing. Engineers calculate the trajectories of test dummies and other objects launched during crash tests to assess vehicle safety.