

Throwing a softball well takes skill, patience, and practice; however, one might not realize how mathematics can be applied to real life scenarios, such as sports. Any path that an object tends to take, whether it is thrown, kicked, punted, shot, or even hit, is defined as projectile motion. Specifically, when a ball is thrown, the shape that the ball makes while in route to its destination is called a parabola. Although there is no one specific way to make a “perfect throw” for everyone, it is not true to say that the optimal angle of release of 45 degrees will achieve the greatest distance in the least amount of height and time (mrfizix.com). The optimal angle of release is different for every person because it ultimately depends on the velocity and distance that one wants to throw. Interpreting the parabolic shape of a throw is very important when determining whether a throw has enough velocity and time to reach a certain destination on the field. Mathematics certainly exists in the game of softball.

A regulation softball’s circumference is 12 inches, or 30.5 centimeters. The balls are colored yellow with red thread and are made up of a combination of cork and rubber. A regulation softball weighs between 6.25 ounces and 7 ounces (wiki.answers.com). When preparing one’s self to throw a ball with the angle that is most effective for her to appropriately throw, it is important to remember four steps to ensure that the throw will achieve its maximal speed per second. First, the fielder’s body should be perpendicular to the target that she is throwing to. While the ball is in the glove, the fielder should grip the softball across the seams with her index and middle finger. Next, the fielder should adjust her weight from being balanced or equal on both feet, to shifting her weight onto her throwing-arm foot and look at her target. Third, the fielder begins the actual motion of the throw, where the fielder’s weight is now transferred forward as her body exerts energy from her throwing-arm foot to the opposite foot. Finally, the fielder releases the ball from her hand and allows her arm to follow through across

her body. Because all of the fielder's weight has been transferred forward, the throwing-arm foot will follow through forward generating the fielder's body to now be parallel to the location she is throwing to (en.allexperts.com). Projectile motion exists every single time a fielder throws a ball. This means that throughout one 7 inning softball game, hundreds of parabolic shapes are created because of projectile motion. The size of the parabola produced, however, depends on the velocity applied to the throw and the distance she is from her target. When disregarding air resistance, the path of a softball thrown from an initial height h with initial speed V_o and angle of elevation θ , can be depicted from the following two equations:

$$x = (V_o \cos \theta) \times t$$

$$y = h + (V_o \sin \theta) \times t + \left(-\frac{1}{2} g \right) \times t^2$$

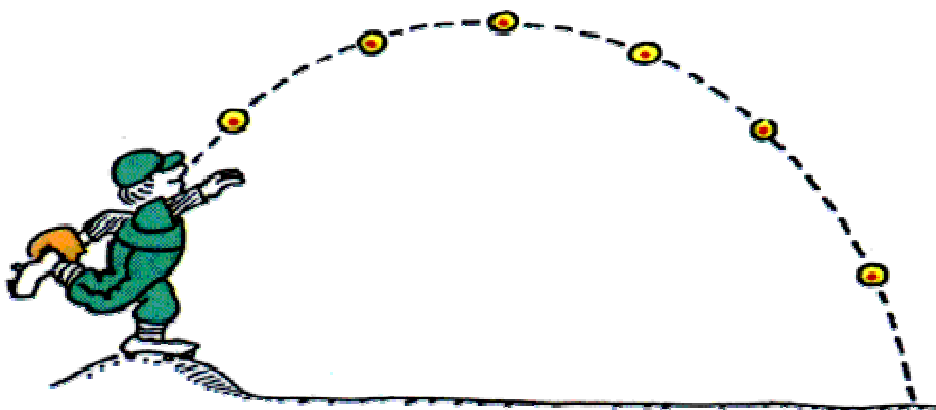
By adding the two equations together, we can determine the initial position of the ball.

$$x+y = [(V_o \cos \theta) \times t] + [h + (V_o \sin \theta) \times t + \left(-\frac{1}{2} g \right) \times t^2]$$

Note: Because bases on the softball field are measured in feet, we will define gravity as 32 ft/sec/sec.

Geometrical shapes consisting of a single bend and two lines going off to an infinite distance define a parabola. The standard equation of a parabola is $Y = Ax^2 + Bx + C$ or $X = Ay^2 + By + C$, where $A \neq 0$, polynomial functions of degree 2. The vertex of a standard parabola is $(0,0)$ and its line of symmetry is $X=0$. If an image or graph can be reflected over a line, and the figure appears unchanged, the line then becomes its line of symmetry. The standard equation to find a vertex of any parabola is $X = -B/2A$, using these results you then plug the X-value into the

given equation to find the Y-value, which then gives you the coordinates to the vertex. To find points on the parabola all one must do is plug different X-values into the equation and that will give you the Y-values.



Angled projectile motion is basically another name for the parabolic shape that a ball takes when thrown at an angle. This type of projectile motion is unique because its beginning and ending heights are the exact same. Therefore, the projectile's change in vertical distance will always be equal to zero. A softball takes a parabolic shape when thrown because of gravity. Without gravity, the ball would travel in a straight line at a constant velocity, forever. Gravity, in opposition, makes the softball travel toward Earth. The range is the distance that the softball travels horizontally when it returns to the initial height from which it was released. When a softball is thrown, it has both vertical and horizontal velocities. Throughout the entire trajectory, or path in which the ball takes through space, the horizontal velocity components remain constant, while the vertical velocity components change. At the top of the parabola, vertical velocity now equals zero because of the effects that gravity has on it. Once the vertical velocity is equal to zero, gravity then begins to exert a downward velocity on the softball until it reaches

the ground. The projectile's upward speed is equal to its downward speed. The only true difference is the direction of the motion that the ball takes (mrfizix.com).

Parabolas can have different forms, it can be stretched up or down, or its width can change. Our experiment tested just that. We had three female students throw a standard size softball from three different distances: 43 feet, 60 feet and 84.85 feet. We had two students who were on the girls' softball team and one who was not very athletic. We did this to see if there was a difference in the parabola that the throw would make and also to see the differences in velocity. We recorded the throws at the varying distances and uploaded them to Logger Pro. We then traced the ball's movement in each of the videos, and then used Logger Pro to fit a line to the curve. The data we received from the program included the points and the velocity at each of the points. By tracing the points, we realized that there was a more "definite" parabolic shape for the participant who did not have experience throwing a softball.

When a ball is thrown at a steeper angle, its range will consist of more vertical direction than horizontal. And, when a ball is thrown with a shallower angle, its range will consist of more horizontal direction than vertical. When a ball has a longer hang time, which exists when the ball is thrown with a steep angle, the ball will travel less distance than a ball thrown with less hang time and more horizontal direction. Thus, when the angle at which the ball is released changes, the total distance, the time, and the maximum height are all affected (howstuffworks.com).

Air resistance affects the projectile motion of a thrown ball because friction exists between the ball and the air as it travels through it. Air resistance tends to slow the ball down slightly (www.scienceclarified.com). When a softball follows its parabolic path, the ball's

movement in the vertical direction is manipulated by gravity. As the ball is accelerating upward, gravity will slow it down slightly until it concisely stops at its highest point. The ball will then continue to travel downward, until it reaches the ground. This is standard for every softball thrown, no matter how far away the target location is. The horizontal and vertical velocity components are independent of one another. In other words, a vertical force exerted does not affect the horizontal motion of the ball (physicsclassroom.com).

We will be given the velocity in units of feet per second. It is commonly heard, however, that the velocity describing a throw is given in units of miles per hour. This simply means that we must convert the unit of feet to miles and the unit of seconds to hours. This can be done in one complex conversion equation...

For example, if a velocity given were to be 45 ft/sec, we would convert it to miles/hour by...

$$45 \frac{\text{feet}}{\text{sec}} \times \frac{1 \text{mile}}{5280 \text{feet}} \times \frac{60 \text{sec}}{1 \text{min}} \times \frac{60 \text{min}}{1 \text{hr}} = \frac{675 \text{miles}}{22 \text{hour}}$$

$$\approx 30.68 \frac{\text{miles}}{\text{hour}}$$

A simple conversation can help one to understand the velocity described in a unit that many are more familiar with, miles per hour, rather than feet per second.

In conclusion, when a softball is thrown, it follows a parabolic path, or trajectory. The horizontal and vertical components of a softball being thrown are independent of each other. Also, when the vertical velocity reaches its highest height, the velocity equals zero. Although there is no generic or “best way” for everyone to throw a softball, it is important to remember that the angle of release is most important in determining the distance and velocity that one

should throw. To investigate more information about the relationship between projectile motion, the parabolic shape, and throwing a softball, one can visit either

<http://www.physicsclassroom.com/mmedia/vectors/bds.cfm> or

<http://www.mrfizix.com/home/projectilemotion.htm>, where more in depth information can be found regarding these topics. It is clear to see that mathematics exists in the game of softball.

Bibliography

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