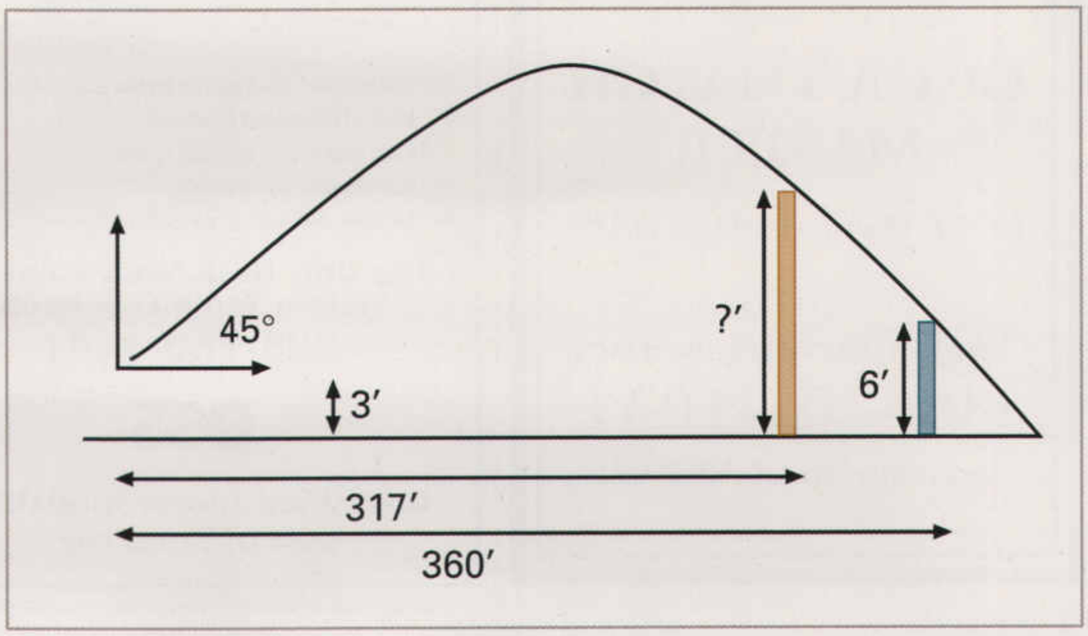
q&a By Dr. Grady Miller, Environmental Horticulture Dept., University of Florida

Finally, physics class is useful!

I'm a landscape architect in the Midwest and have been asked by our client to look for an answer to a baseball geometry problem. They have a Babe Ruth field that needs to have its outfield fence moved back but because of site constraints the left field fence cannot be moved. Instead of moving the fence I believe we can raise its height to make the adjustment to allow for the horizontal dimension (home run or out of the park dimension) change. I know there is a formula for figuring this geometry change but I haven't hooked up with the right source yet. Do you have a reference?

The distances are left, 317 feet; center, 317 feet; and right, 312 feet. Ideally they would like Center to play 360 feet.

Steven S. Ford



Well Steven, I thought this would be a question that would be easily answered but I was wrong. I batted zero with a few turf colleagues and industry representatives. I finally had to sit down with an engineer friend of mine to work through the calculations. I then had a graduate student at Clemson University (also a professional engineer) double-check our answer and suggest something different (based on an assumption we had missed).

So I poured over all these calculations and made a few more adjustments (after reading my old college physics book). Then I faced the most difficult part of solving this problem — how to explain it.

Let me write out what I can that does not involve formulas. First, only one fence distance (317 feet) was used since both left and center is the same. Second, you get the most distance from a ball if it leaves the bat from a 45-degree angle. But realize this is not a simple triangle (a2 + b2 = c2) type problem since the ball moves in an arc. It is what they call in physics, "uniform acceleration in two dimensions." That is almost how I would describe my last bike wreck, when I slowed down quicker than the bike did.

To do this problem you have to work with a couple of equations and variables to calculate movement in two directions. The ball is moving up (later down) which we will label as the "y direction." The ball is also moving out (away from batter) which we will label as the "x direction." The formulas used to solve the problem involve some trigonometric functions [i.e., sine (sin), cosine (cos), and tangent (tan)], but their relationship in this problem and the 45-degree angle simplifies the math. It was assumed that the ball was hit from a 3-foot height. This is important since you have to subtract that height from the height of the outfield fence. Later you will need to add that height back to your answer.

Other than length to the outfield fence and height of the outfield fence, you also have to work with the velocity of the ball (which influences trajectory and time in the air) and gravity. Velocity will have to be calculated, but for gravity (g) we can use the constant 32.2 feet per second. In this case we assumed there is no air resistance. This is a practical assumption for the calculation, but in reality there can be many influences related to airflow. From here on out the answer involves some equations and calculations. If you round your answers, you can have a dramatic influence on the final outcome, so keep the rounding to a minimal.

The diagram gives you some idea how to set the problem up.

The first step is to solve for time (t) to hit the ball 360 feet and clear a 6-foot wall since this is the length the high school wishes the field would play. This will involve solving for time in both the x and y direction.

In the x direction: $t = \frac{x_f}{v \cos 45°}$

In the y direction: $y_f = v \sin 45°\, t - 1/2\, gt^2$

Substitute t from x direction into the first part of the second equation to get:

$y_f = x_f \tan 45° - 1/2\, gt^2$

Solve for time, $t = \sqrt{\frac{2}{g}(x_f \tan 45° - y_f)}$ or

$t = \sqrt{\frac{2}{32.2}(360 \tan 45° - 3)} = 4.68$ seconds

We then determine if it takes 4.68 seconds for the ball to go 360 feet, it only takes 4.13 seconds to travel the 317 feet. Using this information, one can go back and solve the third equation used above.

$y_f = 317 \tan 45° - 1/2(322.2 \leftrightarrow 4.132) = 42.2$ feet, plus 3 feet (initial height difference)

So the top of the fence should = 45 feet 5 inches.

Well, you can see that there is a certain amount of complication in working through this problem since more than one equation is needed. But given the correct equations and a few logical assumptions it can be solved. Who said you would never use what you learned in physics? ST

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