Baseball is known as America’s pastime. It involves taking a bat and hitting a ball across a field that is in the shape of a diamond. Often times, baseball is regarded as a game of numbers, where the best teams can be built by using statistics collected over the careers of various players. The role numbers play in baseball can be taken even further to the velocity the ball travels and the angle it takes off at once the batter hits it. Write a program to calculate the distance the ball travels, how long it stays in the air, the maximum height the ball reaches, whether or not it is a home run, and whether or not it is hit out of the park.

A standard baseball field has a distance of 400 ft between the fence marking the edge of the field and home plate, where the batter is. The fence is usually 10 ft high. A guaranteed homerun will pass the edge of the field at a height greater than the fence, where an outfielder may intercept it. For this particular stadium, for the ball to make it out of the park it must clear a distance of 200 feet beyond the field’s edge while additionally having a height exceeding the 30ft catch net.

A chronometer is used to measure the horizontal velocity of the baseballs being hit by the various players. A high speed camera is used to determine the angle with respect to the horizontal plane that the ball is struck at. The typical strike zone where the ball makes contact with the bat or misses is between 1.6ft and 3.6 ft.

Test your program using the data below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Player** | **Initial Horizontal Velocity** | **θ** | **Bat Contact height** |
|  | (feet/sec) | (degrees) | (feet) |
| 99 | 161 | 20 | 3.5 |
| 42 | 176 | 15 | 2.7 |
| 37 | 139 | 27 | 1.9 |
| 68 | 150 | 22 | 3.1 |

In order to write the program we must consider first the parameters that need to be set to qualify a home run and knocking the ball out of the park.

From the problem statement, it can be said that if the ball height at 400 ft is greater than 10 ft, it is a home run.

It can also be said that if the ball height at 400ft plus an additional 200 ft is greater than 30 ft, it is knocked out of the park.

So, we may define parameters as follows:

\*Note the last 2 parameters cannot be programed until there is either a numerical or mathematical definition for ytw and ytp.

The height of the ball is obviously a function of time, but in order to determine how it varies with time, we must define the input variables.

The input variables that alter between players will be the horizontal velocity of the hit ball, the angle the ball is hit at, and the height that the ball makes contact with the bat.

We can define these variables as:

In order to calculate our desired quantities, we will use the simple kinematics equations from physics that describe projectile motion. We can make the assumption that wind and air resistance are negligible for a baseball.

We also know that horizontal and vertical motion behave independently, so given a velocity and an angle, we may break our velocity into horizontal and vertical vector components.

Because the chronometer only measures, horizontal velocity, we already know the horizontal velocity of the ball. The initial vertical velocity of the ball can be given by the following equation:

The ball will experience the force of gravity acting on it in the vertical direction, but should not experience any forces acting on it in the horizontal direction. So vix will be constant.

This means that the time it takes the ball to reach the fence is simply the distance from homeplate to the fence divided by the initial horizontal velocity of the ball.

Given by:

And the time for the ball to leave the park is given by:

Knowing the time it takes for the ball to either reach the fence or leave the park allows us to calculate the height of the ball when it does reach the fence or the edge of the park, because the height of the ball is a function of time.

From the basic equations of projectile motion:

Where:

In our case the baseball is being hit on Earth, where the acceleration due to gravity is –g, the gravitational constant.

Define:

So, finally, ytw can be given the mathematical definition as follows:

And for ytp

We can now determine whether or not we reached a home run and/or knocked the ball out of the park.

Next we can determine how high the ball travels.

Using the equation of motion:

It can be assumed at the maximum height the ball travels, its final vertical velocity is 0 due to it decelerating due to gravity, so we can write the equation:

Which simplifies to

Next we can determine the balls travel time from the following equation of motion:

Where y is the change in height, assuming a level surface, the final height of the ball will be 0 ft.

So we can write this as

Where *t* is the travel time of the ball. And all other values have previously been specified

Noticing that solving for *t* is the same as solving the roots of a quadratic equation, we can rearrange this and use the quadratic formula to determine the travel time:

The final value that needed to be calculated was the horizontal distance the ball travelled, which is simply calculated by multiplying the horizontal velocity by the travel time as follows: