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STUDENT VERSION
Whiffle Ball Fall

Brian Winkel, Director SIMIODE
Chardon OH 44024 USA
BrianWinkel@simiode.org

Abstract: We are given data on the time and position of a whiffle ball as it falls to the ground. We attempt to model the falling ball and we confront the different resistance terms and models. Finally, we introduce a new way of comparing models, the Akaike Information Criterion, and apply it to our models.

SCENARIO DESCRIPTION

We are given data on time and position of a free falling whiffle ball (see Figure 1) from a university laboratory in Table 1. We will make a mathematical model of this phenomenon and estimate the parameters in the model. We shall also compare the model's predictive power with the actual data.

The teacher who wrote up this experiment [1] his students conducted, says,

> To begin, teams of students are given a few softballs, a few whiffle balls, a strip of paper (at least 20 feet long) marked at every foot or half-meter, a pad of large adhesive paper, foam pads to minimize bouncing (optional), and a long tape measure. Each student is also asked to bring, if possible, a digital camera. On the day of the activity, the class meets at a place (or places) suitable for dropping balls from various heights. Open stairwells or sets of balconies do well. Naturally, safety is a consideration, since softballs falling large distances can be dangerous.
>
> Each team hangs the long strip of paper so that it touches the ground, and someone goes to a spot where a softball and a whiffle ball can be dropped simultaneously in front of the lined paper. The distance from this point to one of the lines on the paper is measured, recorded on adhesive paper large enough to be readable from a photograph, and placed on the chosen line. As the balls are dropped, the other members of the team photograph them against the backdrop of the lined paper before the softball lands. With a little practice, students seem to be able to get useful data from about half their attempts, though capturing both balls in

Figure 1. Whiffle ball lying on the ground next to a bat used to propel the ball in competition.

the same photograph is difficult from large heights. The team repeats this procedure from at least four different heights, perhaps capturing more than one photograph from each.[1, p. 58]

The mass of the whiffle ball is not given, nor are its dimensions.

Activity 1

Create a Free Body Diagram of all the forces acting on the whiffle ball. Be sure you make assumptions clearly and use the assumptions.

Activity 2

Use Newton's Second Law of Motion which states that the sum of the forces acting on a body are equal to the product of the body's mass and acceleration to produce an equation in which one side is $my''(t)$ where $y(t)$ is the distance fallen (in ft) at time t (in sec) and m is the mass of the whiffle ball. Comment on the reasonableness of your model.

Activity 3

Attempt to solve your model in Activity 2. If you cannot solve it analytically then put in some numbers. Reasonable numbers for mass of a 20 g and its diameter is 7.2 cm.[2] Be aware that the units in the data given are in feet and seconds! This will be significant in any analysis you do beyond this point. you may rightfully assume the ball is at rest and has no velocity when the experiment start as it is merely dropped from a given height.

Time (s)	Distance (ft)
0	0
0.32601	1.6154
0.72587	8.0730
0.86624	11.3219
0.97305	14.2320
1.18558	20.0783
1.28771	23.4167
1.41354	27.3056
1.61894	34.1013
1.76001	39.3958

Table 1. Time and position data on a free falling whiffle ball which is dropped from rest.

Activity 4

Estimate the parameters in your model using the data to help you and then to verify the reasonableness of your estimates.

Activity 5

Offer a plot of your model with parameters estimated with the data to give a visual as to how good your modeling really is.

REFERENCES

[1] Brand, N. and J. A. Quintanilla. 2013. Modeling Terminal Velocity. *The College Mathematics Journal*. 44(1): 57-61.

[2] Rossmann, J. and A. Rau. 2007. An experimental study of Wiffle ball aerodynamics. *American Journal of Physics*. 75(12): 1099-1105.