www.simiode.org
SIMIODE
A SYSTEMIC INITIATIVE FOR MODELING INVESTIGATIONS
& OPPORTUNITIES WITH DIFFERENTIAL EQUATIONS

STUDENT VERSION
SHUTTLECOCK FALL

Brian Winkel
Director SIMIODE
Cornwall NY USA

STATEMENT

Figure 1. Shuttlecock, the flying object used in the game of badminton.

We are given data on time and distance traveled below the starting height of 2 m of a free falling shuttlecock (see Figure 1) 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.

1. Draw a Free Body Diagram with all the forces acting upon the shuttlecock as it falls.
2. Use Newton's Second Law of Motion which states that the sum of the forces acting on a body is equal to the product of the body's mass and acceleration to produce an equation in which one side is $m\,y''(t)$, where $y(t)$ is the positive distance fallen (in m) at time t (in sec) and m is the mass of the shuttlecock. Comment on the reasonableness of your model.

Time (s)	0	0.347	0.47	0.519	0.582	0.65	0.674	0.717	0.766	0.823	0.87	1.031	1.193	1.354	1.501	1.726	1.873
Distance (m)	0	0.61	1.00	1.22	1.52	1.83	2.00	2.13	2.44	2.74	3.00	4.00	5.00	6.00	7.00	8.50	9.50

Table 1. Time and distance traveled data on a free falling shuttlecock which is dropped from a height of 2 m at rest. Source [1].

3. Knowing the fact that this experiment was done in Villanova PA USA find a way to estimate all parameters in your model.
4. With these determined parameters compare your model with the data.
5. Check with others or perhaps look up some on-line efforts with modeling falling bodies (with and without resistance).
6. Compare your different models and comment on them.

REFERENCES

[1] Peastrel, M., R.Lynch, and A. Armenti, Jr. 1980. Terminal velocity of a shuttlecock in vertical fall. *American Journal of Physics*. 48(7): 511-513.