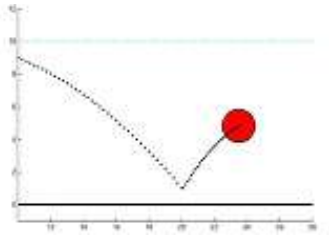
MOTION OF BALLS

Ann and Tom wonder how the surface on which a ball bounces affects its bounce. They discuss what happens to a ball that is dropped vertically onto a flat horizontal surface, and which falls under the influence of gravity. Finally, they are convinced that acceleration of the ball increases as the ball goes downwards and decreases as it rises. Do you agree?

For deciding if Ann and Tom are really right, you have to investigate the situation carefully. In consequence, there are many questions you could ask:

- What forces act on the bouncing ball?
- What is the highest speed of a bouncing ball and when does it occur?
- Is there a model to describe the height of the ball?
- In which way does the height decrease from one bounce to the next?
- Can you determine how high a ball will rebound on each bounce and make predictions about its motion?



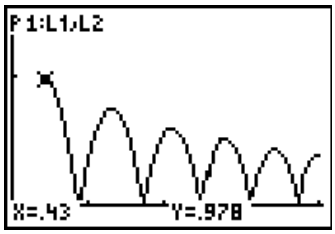
A. Preparation

1) Think about the changes in motion a bouncing ball will undergo as it travels straight up and down. Make a sketch of your prediction for the distance vs. time graph and describe in words what your graphs means.
2) Make a sketch of your prediction for the velocity vs. time graph and describe in words what your graph means.
3) Make a sketch of your prediction for the acceleration vs. time graph and describe in words what your graph means.

B. Observation of an experiment

Preliminary experiments:

1) Have one person hood the motion detector while another person holds the ball at least 20 centimeters beneath the sensor.
2) After setting up the software and releasing the ball you will get a distance vs. time graph which looks differently from the picture on the right.
3) Trace the graph and find out what the data indicate according to the experimental setup.
4) Process the data in a way that you get a plot like that shown in the picture.



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C. Modeling the situation in the laboratory

1) Analyze the forces on the ball. Predict the acceleration as a function of the ball's height.
2) Setup the experiment and release the ball. Display the data as in the figure above, so that you can find out the current height of the ball measured from the bottom surface when you trace the graph.
3) Vary the initial height of the ball, make correspondent measurements and determine the acceleration of the ball from the obtained graphs for each run and record your data in a table.
4) Vary also the material of the surface on which the ball bounces.
5) *Extension:* Deliberate with your group members what other factors could influence the bounce and, if possible, make same further experimental runs.

D. Evaluating the data obtained

1) Select the data for each complete bounce from the total set of data to obtain the parameters for the ball's movement from these sections. Fit appropriate functions to the data both for distance vs. time graphs and velocity vs. time graphs.
2) Determine the acceleration of the ball using the functions produced in D1.
3) Explain how the functions of the second and the third parabola are similar, how they are different. How are the parameters obtained from the functions' equations connected to the movement of the ball?
4) Explore if the following statement is right: The maximum height decreases exponentially from bounce to bounce for each ball and its initial height.

1) *Extension 1*: Find a function that models the data as following: maximum height as a function of time.
2) *Extension 2*: If the ball is both large and light enough, the buoyant force and air resistance may affect the acceleration. Perform the curve fitting and statistical analysis techniques, but these times analyze each half of the motion separately.

E. Show your results

1) Determine the consistency of your acceleration values and compare your measurement of g to the accepted value of g. How do the fitted curves for the upward motion compare to the downward motion? Explain any differences.

2) *Extension:* Instead of dropping ball and let it bounce on the ground, imagine a ball thrown upward, again with the motion detector positioned above the ball. Predict what the three motion graphs will look like.