A REBOUNDING TROLLEY

Is the rebounding trolley constantly accelerated?

Investigate the motion of a rebounding trolley and answer the following questions and also find some more questions by your own:

- How can you derive the velocity of the trolley?
- What forces are acting on the trolley and what is their impact on the motion of the trolley?
- Which parameters influence the motion of the trolley?

A. Preparation

Paper & pencil activity:

1.) Make a sketch for the graphs of distance as well as velocity against time prior to the experiment (according to the experimental setup above).

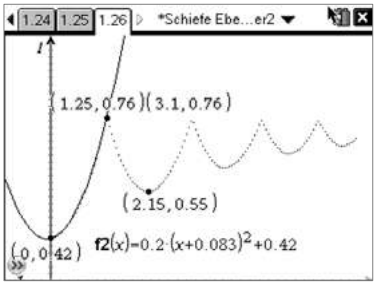
2.) Identify on the graph, parts representing the trolley movement down and respectively up the runway as well as the collision points.

B. Observation of an experiment

Preliminary experiments: Move the trolley by hand up and down the runway in the following different ways and observe the shape of the graph in each case, particularly showing the forwards and backwards motion:

- a constant velocity away from the sensor,
- a faster or slower constant velocity,
- an acceleration,
- a deceleration,
- an oscillation.

C. Modeling the situation in the laboratory



1) Assemble the apparatus, as shown above, so that the trolley with an attached buffer can move up and down a sloping runway. Then, release the trolley and collect data for a few seconds.

2) Associate the features of the obtained graph with the observed motion by tracing the graph and identifying interesting points on the graph. Check the results according to your prediction in part A. In order you were not right, explain what mistakes you made.

3) Describe the pattern you can find when looking at the distance vs. time graph and explain the shape according both to the experimental setup and the underlying physics concepts.

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4) Discuss with your group what parameters could have an effect on the motion and investigate the motion of the trolley in more detail. Make predictions, set up an appropriate experiment, collect data with the motion sensor, and test your predictions.

5) Take a closer look at the half loops: Try to find polynomial functions fitting the different parts of the graph and find out if it is possible to customize parabolas agreeable to the obtained data.

6) *Extension 1*: Describe the pattern you can find when looking at the velocity vs. time graph and explain the shape according both to the experimental setup and the underlying physics concepts.

7) Extension 2: Describe the pattern you can find when looking at the acceleration vs. time graph and explain the shape according both to the experimental setup and the underlying physics concepts.

D. Evaluating the data obtained

1) Describe the shape of the distance vs. time graphs in general and identify interesting points and sections on the graph. For example, identify both the points were the trolley hit the fixed barrier and were the trolley came to rest after rolling up the runway.

2) Explain the shape of the distance vs. time graphs and describe the forces acting on the trolley.

3) Explore also the velocity vs. time graph and find the point where the trolley reaches maximum velocity. Does this value depend on the mass of the trolley?

8) Make a sketch for the acceleration vs. time graph and test your prediction. In order you were not right, explain what mistakes you made.

4) Explain how the forces acting on the trolley are combined to produce the resultant force. Further, describe the relationship of resultant force and velocity of the trolley.

E. Show your results

Thinking about your observations, discuss the correctness of the following statements:

a) The force of gravity on the trolley remains constant throughout the motion.

b) The force of gravity has a component down the slope in the direction of motion.

c) The force of friction depends upon the velocity of the trolley.

d) The resultant force is always in the direction of motion of the trolley.

e) The acceleration is always in the direction down the slope.