# To investigate the affect a changing slope has on the distance traveled by a toy ...

This experiment involves three major factors, gravitational potential energy, kinetic energy and friction. Advancing Physics by Jon Ogborn and Mary Whitehouse has, I feel, the best explanation of the relationship between gravitational potential energy and potential energy. They use a tennis ball as an example:

HYPOTHESIS: The significant variables for this experiment are:

Height of car at start – gravitational potential energy

Mass of car used – gravitational potential energy

Car used – axle friction, wheel width and diameter,

Aerodynamics etc. may differ on different

Models

Texture of ramp – friction

POSSIBLE INDEPENDANT OR CONTROL VARIABLES: Height of car, Mass of car, Texture of ramp (very difficult to measure).

POSSIBLE DEPENDANT VARIABLES: Distance traveled, Average speed.

As said in my background information decrease in potential energy, or the car going down the ramp, is equal to the increase in kinetic energy that is the car accelerating down the ramp. The height of the car at the start should therefore be proportional to the distance traveled, frictional forces ignored.

PREDICTION: I predict that, assuming no friction on the ramp, distance traveled is proportional to height of car at start, or amount of gravitational potential energy. That is to say when you double the height of the car, you double the distance traveled. As energy cannot be created nor destroyed we see that the friction that produces the heat comes from the kinetic energy of the car, such that The energy that has been converted to heat will reduce the energy going to kinetic energy, bringing the car to a gradual rest.

So friction on ramp excluded:

mgh = 1/2mv2 thus 2(mgh) = mv2

PRELIMINARY WORK: For my preliminary work, I tested each of the possible independent variables, to find the one that suited the investigation best. I tested the weight, by attaching weights onto my chosen car with plasticine. The results were as follows:

Car released at height of 100mm

MASS (g)

DISTANCE (mm)

45

815

55

835

65

765

75

740

These results were not broad enough for a graph. This may be a good possibility for further experiments.

There were only two experiments possible for using friction as the independent variable; these were onto ramps laid out and onto a cutting of easy clean carpet. The results were as follows:

Car released at height of 100mm

MATERIAL

DISTANCE (mm)

CARPET

43

RAMPS

800

This experiment lacks potential as there are only two different tests you can do. Friction is also very difficult to measure unless as a calculated error.

At this point in the preliminary work I decided to go from the slope directly to the desk as the desk would cause less friction as it was polished, as opposed to going from the slope to more ramps of the same material laid out flat. Having not been very satisfied with my results for the other two possible independent variables, I stacked my hopes up that the height would be a good one to choose, and it was. I tested to establish a range of values to work within when it came to actually doing the experiment. I wanted to limit myself to less than two metres from the bottom of the ramp for distance traveled. My results were as follows:

HEIGHT (mm)

DISTANCE (mm)

130

> 2000

120

1943

10

–

20

–

30

330

My range is to be from 30mm – 120mm. I am to test height.

APPARATUS:

Ruler

Stand with clamp

Ramp

Desk

Toy car

METHOD: The ramp will be placed on the desk and attached to the stand via the clamp, the height will be taken from the starting line, 420mm up the ramp from the bottom, to the desk surface and adjusted until the desired height is achieved. The car will be placed with the front of it on the starting line facing down the ramp. The car will be released and a measurement taken from where the care gets to, to the bottom of the ramp. Readings will be taken every 10mm height, between 30mm and 120mm; three readings for each interval unless an anomaly is spotted in which case a fourth test may take place. If the car goes off the side of the desk or collides with the wall running alongside the desk, the test will be void, and have to be redone.

My experiment will be a fair test as the car will be the same throughout, keeping mass and axle friction constant, as will the desk surface and the ramp. Safety is not a key element in this experiments, accidents may be caused by carelessness and lack of attention, such as knocking the stand onto one's toe, I will be extra-vigilant to avoid these.

From my preliminary work I decided on the surface to be used and the independent and, subsequently, control variables. I also ascertained my range of values. A suitable degree of accuracy for measurements of the distance traveled is cm.

RESULTS:

HEIGHT of start (cm)

DT (cm) test 1

DT (cm) test 2

DT (cm) test 3

DT (cm) test 4

12

199

196

199

11

175

176

176

10

162

163

161

9

144

141

138

8

130

128

131

7

112

109

113

6

100

93

92

90

5

70

67

71

4

46

48

47

3

27

27

28

–= Anomalous result

I felt that due to the unfortunate crudeness of the equipment we were given to use, centimetres were as accurate as it was necessary to go. From my graph you can see clearly that the trend is a straight line. It does not, however, go through the origin, without error it would.

There is one obvious anomaly, which could have been caused by any number of things, most likely it found a path down the ramp and along the table that was smoother than the paths taken by the car during the other tests. This is shown on the table and ‘ ringed’ on the graph.

ANALYSIS:

The gap between the line of best fit meeting the ‘ x’ axis and the origin must therefore be error due to friction of the wheels on the surface, and axle friction, besides drag which, I might add, would be negligible on a scale of this size. Another cause of constant error was the fact that I could not find the car’s centre of gravity, and it would have been futile to try, so I started with the front of the car on the starting line instead of the centre. The error seems to take up 1. 4 units in the ‘ x’ axis.

Two points on the line of best fit, are test two for 5cm height, and test two for 10cm height. We must subtract 1. 4 from these results to reduce error leaving us with:

8. 6

163

3. 6

67

We can now prove proportion, excluding error, by doing the basic sum 8. 6/163 and 3. 6/67 leaving us with 0. 0528 and 0. 0537, these results being the scale factors are very similar in fact having just 0. 0009 between them. This negligible error was probably created due to a very small inaccuracy in the plotting or simply the thickness of the line. I like to think the latter! My results have thus supported and/or proved my prediction.

EVALUATION: My experiment was sufficient to prove my prediction but there was quite a large amount of constant error to be subtracted. I thing that it was as good as it was possible to make it with the equipment on offer. There are a tremendous amount of insignificant factors, which would produce a slight error in my experiment. Everything to do with friction produces error, but the experiment was on stopping distance and, in a friction free world, a car let go down a ramp, at any height, would have an infinite stopping distance. Introducing bearings into the car, or simply oiling could reduce axle friction. Excessive polishing could reduce desk friction; air resistance by doing the experiment in a vacuum and so on. A toy car complete with ball bearings on the axles could have been acquired, but at pointless expense. A polished desk would have helped reduce the error but it takes a lot more time to polish a desk than it does to subtract a bit of extra error. And a vacuum on the scale that we are talking about for my experiment would not have been possible as perfect vacuums are very difficult to achieve and the school can certainly not facilitate such a thing. My results contained one obvious anomaly it was higher than the other three readings for this height value. This would indicate a small accidental push on releasing the car. As it only happened once there was no need to devise a means for the car to be electronically released. I could further extend the experiment by changing the mass, or measuring the acceleration of the car down the slope or the average speed.

CONCLUSION: This experiment not very accurate, however, a constant error having been established from the graph, the results became useful. There was no need to refine the method further as I managed to prove my hypothesis and any other apparatus for reducing the constant error was not available to me. I conclude that, when friction is ignored, distance traveled is directly proportional to height.