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Candidate number: 2671

Physics Investigation

Introduction

In my investigation I intend to gather enough evidence and explanation to see if and how the mass of a ball will affect its stopping distance.
I will carry out a series of tests starting with changing the mass of the ball then changing height which it's dropped from.

Predictions

I predict that the mass of a ball will most defiantly affect the distance it takes to stop because as the mass increases, the amount of friction with the surface will increase which will slow down the ball sooner.
I believe if the mass of the ball is doubled the friction with the surface it's on will double and therefore half the distance taken to stop.

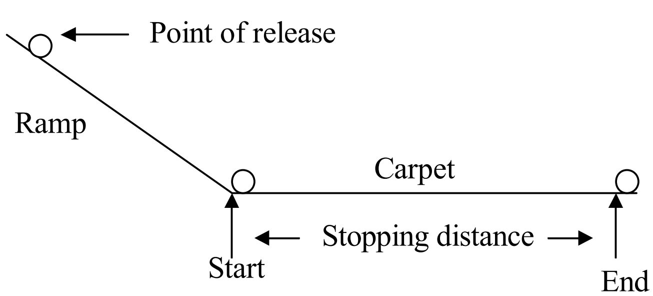
Equipment

For my investigation the equipment I will require is:

- *A ramp and stand (1 metre long)*
- *Carpet (2 by 0.5 metres)*
- *2 balls of different masses but same size (ball 1, 2.8g and ball 2, 44.9g)*
- *2 metre rules*

My setup

My setup is pretty simple I will use a ramp with a rule along it and some carpet for the balls to roll along I will then use another rule to measure the distance taken to stop.



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When I first set up my equipment the balls where rolling around everywhere, to overcome this problem I decided to curl the carpet into a half bowl shape the balls then rolled smoothly down the ramp and along the carpet.

Procedure

Firstly I will drop the lighter ball 1, and measure its stopping distance and record this result; I will then drop the same ball another 4 times and record those results. I will average the 5 repeated results in order to gain a fair distance for the stopping distance of each ball. I will then repeat this with ball 2 and accumulate an average. All other variables for now will be kept the same (i.e. gradient of ramp, height dropped from)

Test 1

In my first test I will be testing ball 1 of radius 2 cm and mass of 2.8g, against ball 2 of radius 2 cm and mass of 44.9g. I will be dropping the ball from 30cm up the ramp with gradient of 24.4°, my results are:

	Ball 1 (cm)	Ball 2 (cm)
1	115	83
2	99	84
3	108	84
4	114	87
5	112	88
Average	109.6	85.2

Analysis

My first test supports my prediction that the mass of a ball does affect the distance that it takes to stop, although ball 2 is over 16 times heavier so I would have expected the stopping distance to be shorter.

Test 2

Again I will use ball 1 and ball 2 but this time I will drop them from a height of 40cm up the ramp with gradient 24.4°, my results are:

	Ball 1(cm)	Ball 2(cm)
1	137	94
2	122	100
3	130	98
4	123	101
5	121	102
Average	126.6	99

Analysis

As I expected when the dropping height was increased the relationship is the same just the distances are longer, I soon realised a fatly floor in my experiment the 2 balls were made out of 2 different materials so the coefficient of friction between the 2 balls and the surface would be different for each ball making my investigation unfair and inaccurate.
I decided to use a toy car and change the mass of the car by adding weights to it, this will mean that the coefficient of friction will be the same for all my tests.

New equipment

- toy car
- weights
- blue tac (to attach weights to car)

Test 3

Here I will be using the toy car of mass 17.4g, and I will add 17.4g so the cars mass will have doubled and I will further use the car plus 100g to see how this affects the stopping distance, my results are:

	Car no added mass (cm)	Car plus 17.4g (cm)	Car plus 100g (cm)
1	187	172	269
2	190	189	259
3	189	184	265
4	190	178	274
5	189	181	264
Average	189	180.8	266.2

Analysis

*From these results it is clear that my prediction is only partially correct as the mass of an object does affect its stopping distance but the relationship is not as linearly as I expected, as the mass is doubled the stopping distance is not halved this is due to the momentum that the object gains, when more mass is added the object gains more momentum proven with the momentum formulae momentum = mass * velocity, so the object will travel feather with more mass, this will explain why when the mass of my car had an extra 100g it travelled a further 77.2 cm. although its not that simple because we have to take into account friction, as the mass increases the gravitational pull of the earth will increase which in turn increases the amount of friction between the car wheels and the surface they roll on and a greater friction will slow down the car and reduce its stopping distance, this will explain why when I added only 17.4g the stopping distance was less . In theory there should be a certain mass that when added to an object the stopping distance will not change as the amount of extra momentum it gains will be cancelled out with the increased friction. I will extend my investigation to try and work out this quantity of mass.*

Test 4

Here I will again be using a toy car and I will change the mass using weights from 20g up to 90g, dropping the car from a height of 10cm and gradient 24.4°.

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	Total mass of car (g)							
	20	30	40	50	60	70	80	90
	Distance taken to stop (cm)							
1	218	201	185	207	199	220	209	221
2	219	213	195	207	204	210	199	219
3	222	217	203	204	210	214	213	220
4	220	214	208	205	209	219	212	217
5	227	213	204	209	211	216	209	219
Average	221.2	211.6	199	206.4	206.6	215.8	208.4	219.2

Analysis

Analysing my results soon after the test I noticed a pattern within my results, although at mass 80g this was not true I decided to repeat the 80g run and found that the distance was actual higher and fit in with my other results.

	Total mass of car (g)							
	20	30	40	50	60	70	80	90
	Distance taken to stop (cm)							
1	218	201	185	207	199	220	215	221
2	219	213	195	207	204	210	219	219
3	222	217	203	204	210	214	220	220
4	220	214	208	205	209	219	216	217
5	227	213	204	209	211	216	217	219
Average	221.2	211.6	199	206.4	206.6	215.8	217.4	219.2

Plotting a graph of my results shows the trend more clearly.

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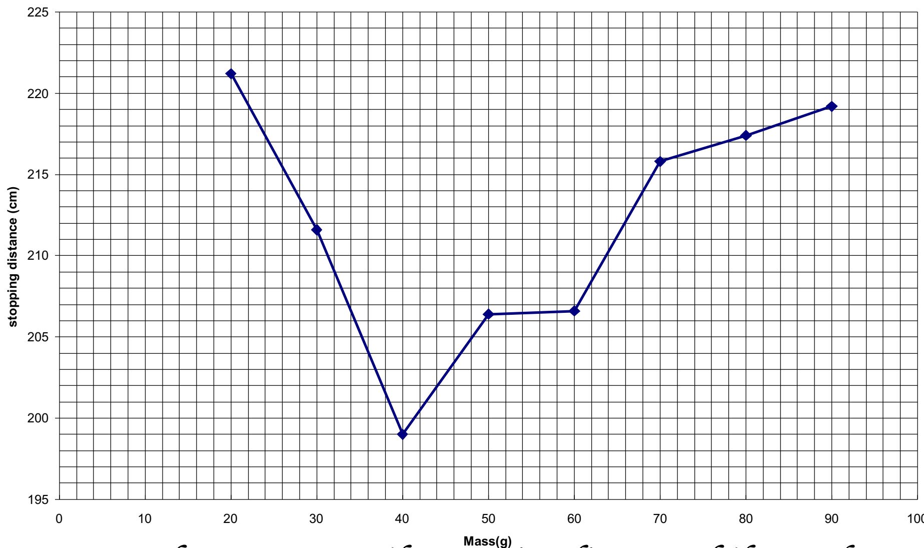
A graph to show the stopping distance of a toy car with different masses.



As you can see from 20g - 40g the stopping distance of the car decreases this is where the extra mass produces more friction than momentum, after this from 40g - 90g the stopping distance increases where the momentum is now greater than the friction, due to time restrictions I will only be able to make an estimate of the extra mass needed for friction and momentum to balance I will base my estimate on the results collected and my graph, the turning point is in between 40g and 50g so I will extrapolate from these to points in order to make my estimate.

Conclusion

In my experiment I aimed to find out whether or not the mass of a ball affects its stopping distance and if so how does it. I started out thinking I knew what was going to happened and that friction was the only point to consider, after my second test I knew something wasn't right and decided to use the toy car, using the toy car was a massive benefit as I could change the mass so much easier and all other variables where kept the same (e.g. coefficient of friction). It was my first set of results with the toy car when I realised I had to take into account momentum this then explained everything about my previous results and everything fell into place. Feathering my investigation out of pure interest I decided to work out the balancing mass of friction and momentum but due to time restrictions I am only able to make an estimate of 42g due to extrapolating my graph. I enjoyed my physics investigation and wish I had more time to further it more.

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