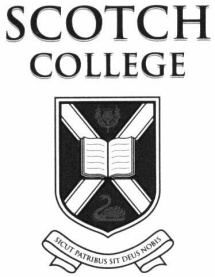
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**Physics Practical Investigation**

**Modelling a car’s stopping distance**

**Introduction/Abstract**

Many drivers think that driving just above the speed limit is not important and don’t care about low level speeding. For example, if the speed limit is 60km/h, they happily drive 5km/h over the speed limit as they know they won’t get pulled over for doing so. However, even just 5km/h significantly increases the chances of an accident or its severity. While most drivers know the dangers of high level speeding most are unaware of how dangerous even low level speeding can be. This is because of two main factors, the decrease in time for the driver to react and also the fact that stopping distance increases significantly as velocity goes up.

For this investigation, ‘The relationship between the stopping distance of a car and its velocity?’ will be investigated. To model this, a marble will be used (acting as the car). It will be on a slope of changing heights in order to change the velocity of the marble. Also a polystyrene cup (acting as the breaks) where the distance travelled by the cup will be measured therefore showing the stopping distance of the marble.

**HYPOTHESIS**

‘The stopping distance of the marble exponentially increases as the velocity of the marble increases with constant acceleration.’

Please note that the breaking distance of a car depends on several factors including the following that are not considered in this experiment.

* The road condition (wet or dry/rough or smooth)
* Vehicle weight (e.g. with or without passengers, load …)
* Tires condition (worn-out or new)
* Tires size (Small, medium or large)
* Road slope (flat, uphill or downhill)
* Efficiency of braking system (e.g. Anti-Lock Braking System …)

Considering ideal conditions, to calculate the braking distance, the following formula can be used:

**V2 = U2 - 2ad**

V=Final Velocity

U=Initial Velocity

a=Acceleration (in this case it is actually deceleration)

d=Stopping Distance

As the “V” should reach zero, then the formula can be simplified to:

**d= U2/2a**

So it means that the “Stopping Distance” has a direct relationship with the square of the speed and it can increase significantly by slight increase in speed. That is why a small decrease in speed can reduce the stopping distance or impact (in case of a collision) considerably.

Using the same reasoning, it is clear that the kinetic energy has the same relationship with the velocity and a slight reduction in velocity can result in much less kinetic energy (as well as energy required to stop the vehicle) as per the following formula:

**EK = ½ mV2**

**VARIABLES**

***Independent variable*:**

The velocity of the marble (which is done by changing the height of the stand which the pipe is clamped to from 15 with 5cm increments).

***Dependent variable:***

The stopping distance of the marble (in turn being the distance that the polystyrene cup travels after being hit by the marble in meters).

***Controlled*** ***variables*:**

* Marble
* Ruler
* Stop Watch
* Stand
* Clamp
* Polystyrene Cup
* PVA Pipe

***Uncontrollable variables:***

* Human error

**MATERIALS**

* Stand (50cm in Height)
* Clamp
* PVA Pipe (105cm long)
* Marble (4.44g and 2cm wide)
* Polystyrene cup
* 2x rulers (30cm)
* Computer (Record results)
* Microsoft Excel Application (Graph results)
* Stop Watch (To 0.1 second accuracy)

**EXPERIMENTAL PLAN**

1. Collect all the equipment as stated above in the ‘MATERIALS’.
2. Setup your stand so that there is at least a meter unobstructed in front of it.
3. Connect your clamp to the stand.
4. Connect the PVA pipe to the clamp so one end of it is on the ground.
5. Setup polystyrene cup horizontally with its open face facing the end of the PVC pipe.
6. Place a ruler next to the end of the PVC pipe (however not obstructing the cup) and tape it down to the floor.
7. Get ready your computer with Microsoft Excel open for recording results
8. Give one person the stopwatch (for recording the time taken for the marble to reach the end of the pipe)
9. Measure the height of the clamp on the stand to 15cm (measure from the bottom of the clamp).
10. Release the marble and at the same time start the stopwatch until the marble reaches the end of PVC pipe
11. Measure the distance the polystyrene cup has travelled and record it.
12. Do steps 10-11 again for second results.
13. Do steps 9-12 however for heights 20cm, 25cm and 30cm and record them in Excel

**RESULTS**

|  |  |
| --- | --- |
| Velocity (m/s) | Height (cm) |
| 17.16 | 15 |
| 19.81 | 20 |
| 22.15 | 25 |
| 24.26 | 30 |

|  |  |
| --- | --- |
| Stopping Distance (m) | Kinetic Energy (Joul) |
| 0.055 | 0.65 |
| 0.1 | 0.87 |
| 0.165 | 1.09 |
| 0.215 | 1.31 |

|  |  |
| --- | --- |
| Stopping Distance (m) | Velocity (m/s) |
| 0.055 | 17.16 |
| 0.1 | 19.81 |
| 0.165 | 22.15 |
| 0.215 | 24.26 |

|  |  |
| --- | --- |
| Stopping Distance (m) | Velocity Square (m/s) |
| 0.055 | 294 |
| 0.1 | 392 |
| 0.165 | 491 |
| 0.215 | 589 |

**DISCUSSION**

Above are four graphs showing the relationships between: Velocity-Height, Stopping Distance-Kinetic Energy, Stopping Distance-Velocity and Stopping Distance-Velocity.

For the Velocity-Height graph, we know the following:

* Gravitational-Potential Energy at the peak is equivalent to Kinetic Energy at the base
* mgh=mv gh=v

Therefore, as seen above, the Velocity-Height graph created has a direct relationship with the square of two times gravity multiplied by height.

For the Stopping Distance-Kinetic Energy graph, we know:

* The formula for Kinetic Energy is:
* The formula to get Stopping Distance () is:=
* = md= =

Therefore, this relationship creates a linear graph between Stopping Distance and Kinetic Energy.

For the Stopping Distance-Velocity graph, we know:

In theory, this formula should create an exponential graph however, if you look at the graph above, it seems to be linear as this is because the sample size for the data was not large enough to show this.

For the Stopping Distance-Velocity graph, we know:

However, in this case, the relationship between Stopping Distance and Velocity is linear as Velocity is squared.

**CONCLUSION**

After processing our data, there were some clear trends in our results showing how speeding exponentially increases your chances of an accident. These results hence support our hypothesis that ‘The stopping distance of the marble exponentially increases as the velocity of the marble increases.’

This can be explained by the formula for stopping distance: **d= U2/2a** as this is an exponential relationship between stopping distance and velocity where for every increase of velocity, there is a squared of that increase in stopping distance. For a further explanation you can either go back to the hypothesis or visit <http://www.nova.org.au/technology-future/physics-speeding-cars>.

**EVALUATION**

As a whole, the experiment went pretty smoothly, with no major barriers or problems encountered when gathering the results. Therefore, the investigation rather successfully achieved the goal of the task by creating the correlations to show the major effects that going over the speed limit has. Also, this shows that our method was successful in guiding our experiment.

In order to make this experiment more reliable, we would have needed to do more than two trials for each height in order to be able to see if any of our data was an outlier from the rest and possibly try and see what went wrong. As with only two data, there is no way of telling if any of the data is wrong. However, from the results that we got, it would be assumed, from the minimal experiments that were done, that the data was quite reliable as we followed the experimental plan well when completing this experiment and there weren’t any clear outliers.

The results are quite precise apart from human error as we can not do anything about that but otherwise all my data is reasonably accurate. However, there still was not enough data to make a reliable justified scientific opinion. But on the other hand, the sample size chosen was good as it was not too large but still enough to show the trend and correlations that was desired to be researched for this task apart from in the Stopping-Distance, Velocity graph as we could not get the desired exponential line.

This experiment was quite reliable as far as results go however, as the task was to re-enact a situation where a car is going 5km over the speed limit and how even low level speeding severely increases his risks of an accident, even though the concept was there for this experiment to portray the scenario, the experiment itself had a lot of flaws. For example, the polystyrene cup acting as the breaks (also used to measure the stopping distance) were very faulty as it would roll rather than move in a linear direction making measuring it flawed. Apart from that, the experimental method itself was very clear and concise making it easy to follow.

For next time, in order to improve this experiment, some changes that could have been made include: the use of a polystyrene cup would be abandoned as a lot of the unreliability of the data came from it, and would have instead used an open topped rectangular prism filled with water as the resistance in water is constant. This would make a reliable stopping distance and source of resistance making this report more dependable.