

# YEAR 10 SCIENCE

# Physics Practical Investigation

# (Modelling a car’s stopping distance)

Introduction  
  
It is said that by going 5 kph over the speed limit a person significantly increases the minimum stopping distance they can stop their car in. It is possible to model this situation by using a marble to represent the car and a polystyrene cup catching the marble to act as the brakes stopping the car.

# Task

You are to conduct a controlled scientific investigation to investigate the factor(s) that influence the stopping distance of a marble rolled down a ramp. A polystyrene cup will be used to represent the brakes.

You will need to research how the motion energy of a car is dissipated when a car brakes.

What equations will be useful?

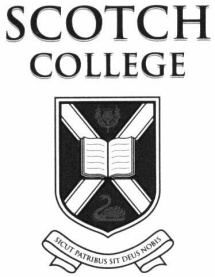
How will you control the speed of your marble?

What data will you need to collect and what graphs will you need to construct?

Can you represent your data by a suitable equation?

# Other Information

* Tables and diagrams should be used where necessary and should be captioned and numbered.
* Data tables will require uncertainties, and graphs equations and error bars.
* References should be cited in the usual manner.
* The investigation will be marked according to criteria B and C of the IB MYP (refer to the links in Coneqt).
* The assignment must be electronically submitted through [www.turnitin.com](http://www.turnitin.com) where the overall similarity index must be less than 30%. You must also provide your teacher with a hard copy of the assignment.

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**MYP SCIENCE**

**INVESTIGATION FORMAT**

**INTRODUCTION**

**(Criterion B)**

Many people think that driving a car just over the speed limit is doesn’t harm anyone and is more beneficial than driving slowly. For example if a driver were to be in a zone where the speed limit is 60km/h they would happily drive 5km/h over the speed limit (known as low level speeding)as they know it is within the law to do so. However what they don’t know is that by increasing their speed by just 5km/h they are significantly increasing the chances and severity of a car crash occurring. While most people know the effects of high level speeding many people are unaware of the devastating consequences of low level speeding. This is because of two factors the faster the driver is moving the less time they have to react to and that stopping distance significantly increases the faster the driver is going.

This investigation will test the relationship between the stopping distance of a car and its velocity. To test this a marble will be used as the car. It will be on a slope of changing heights to simulate different velocities of the car. At the bottom of the slide a polystyrene cup will act as breaks for the marble and the distance that the cup travels will show the stopping distance of the marble.

**HYPOTHESIS**

**(Criterion B)**

The stopping distance of the marble will exponentially increase as the velocity increases

Although this test simulates the stopping distance of a car it is only being tested in one situation with different velocity’s, in the real world there are many factors that could dramatically change the stopping distance of a car at the same velocities that are not considered in this experiment.

* Road condition
* Road angle
* Braking system efficiency
* Tire conditions

Because this test is only simulating the stopping distance in ideal conditions, the following formula will be used to calculate the stopping distance. The following formulas were found [here](http://www.webpages.uidaho.edu/niatt_labmanual/Chapters/geometricdesign/theoryandconcepts/BrakingDistance.htm).

Vf^2=Vo^2+2ad

Vf = Final velocity  
Vo= Initial velocity  
a = Acceleration rate  
d = Distance traversed during acceleration

When calculating the braking distance, the velocity of the marble should reach zero. Because of the formula can be manipulated to the following formula to find the total distance travelled during braking.

d = -Vo2/(2a)

This then shows that the stopping distance has a direct relation to the squared value of the initial velocity and that it can significantly increase with a change in the initial velocity.

Given that the formula has velocity squared a relationship between the velocity and the kinetic energy, and that the increase in the velocity can affect the kinetic energy of the marble. This can be calculated by the following formula. This formula was found [here](https://www.chem.wisc.edu/deptfiles/genchem/netorial/modules/thermodynamics/energy/energy2.htm).

KE = 1/2 mV^2

M = mass (in kilograms)

**VARIABLES (Criterion B)**

List the independent, the dependent variable and the control variables and list these in order of priority.

There are three types of variables that must be considered:

* ***Independent variable*** – The velocity of the marble.
* ***Dependent variable*** – The stopping distance of the marble.
* ***Controlled*** ***variables*** –
  + ***The same***
    - ***Ruler***
    - ***Marble***
    - ***Stop watch***
    - ***Stand***
    - ***Slide (PVC Pipe)***
    - ***Cup***

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**MATERIALS (Criterion B)**

* Retort stand
* Slide (PVC pipe 105cm)
* Cup
* Marble (0.00444kg)
* Ruler
* Sheet (recording results)
* Stop Watch

**EXPERIMENTAL PLAN**

**(Criterion B)**

1. Collect materials (look in materials section of report).
2. Setup retort stand in an unobstructed area.
3. Place slide 15cm off the floor on retort stand.
4. Place cup on its side with the open face on the end of the slide.
5. Place ruler on the end of the slide zero starting at the end of the slide.
6. Release the marble and start the stopwatch at the same time
7. Stop the stopwatch at the end of the slide (record).
8. Measure distance the cup traveled from the end of the slide ()record.
9. Repeat steps 6-8 a second time to record a second set of results.
10. Repeat steps 6-9 with the slide at height of 20cm, 25cm and 30cm and record the result on the sheet.

**RESULTS**

**(Criterion C)**

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

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

**DISCUSSION**

**(Criterion C)**

The above graphs show the four major relationships found within the results (Velocity to Height, Stopping Distance to Kinetic Energy, Stopping Distance to Velocity and Stopping Distance to Velocity)

For the height to velocity graph, we know the following:

That the gravitational potential energy of the marble is the same as what the velocity of the marble is at the end of the slide.

Therefore we can use the formula \* to show that the height to velocity graph has a relation to

\*G = gravity

\*h = height

**CONCLUSION**

**(Criterion C)**

**EVALUATION**

**(Criterion C)**

How well did you think your investigation went? Did you have any problems that you dealt with while carrying out the experiment.

**Reliability: Can you trust the evidence?** Did you collect sufficient and reliable data? What errors are there in your measurements? How precise and accurate do you think that your results are? Did you repeat your readings enough times? Was your sample well chosen and large enough?

**Validity: Were you really able to answer the research question?** Was it truly a fair test? Were you measuring the right things and correctly? Was your experimental method basically OK?

**Improvements:** Write down how you might make your investigation better, especially to improve the reliability and validity i.e. better experimental design or ways of reducing errors. Write down any further experiments you could carry out to get more evidence or to extend this investigation.