SASTA OLIPHANT SCIENCE AWARDS

South Australian Science Teachers Association

Prize Winner

Scientific Inquiry

Year 7-8

Raisa Afsara

Mitcham Girls High School

ROWE SCIENTIFIC PTY. LTD. www.rowe.com.au

Australian Government
Department of Defence

Government of South Australia
Department for Education

SASTA
South Australian Science Teachers Association

How Do Roller Coasters work?

Questioning and predicting:

The question that is being investigated is how roller coasters work. This question will be represented as a marble run as they both have equivalent distinctive qualities.

Aim:

The objective of the investigation is to determine how much energy a marble run need to complete a full circuit before being stuck.

Hypothesis:

Increasing the height of the starting point in a marble run will result in faster speeds and longer distances travelled by the marble, simulating the principles of kinetic and potential energy observed in real-life roller coasters.

Introduction:

Many factors and attributes need to be considered when making a functional marble run. The marble run applies to Newton's third law of motion. The investigation demonstrates physics, gravity, friction, potential energy, kinetic energy, and conservation energy.

Planning and conducting:

Choosing a marble run as an investigation to replicate a real roller coaster can be an accurate and informative approach due to the similarities between the two systems. Both marble and real roller coasters rely on fundamental principles of physics, such as gravitational forces, energy transfer, and momentum. By constructing a marble run, individuals can study these shared principles in a scaled-down, manageable environment, gaining insights into the behaviour and mechanics of real roller coasters. This hands-on experience allows for a deeper understanding of the concepts involved, fostering learning, and facilitating the application of this knowledge when tackling the complexities of replicating a full-scale roller coaster. The variable that is being changed and measured in the investigation is the height.

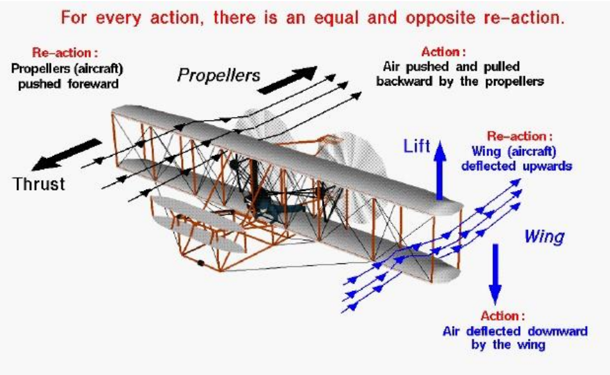
Fair Test:

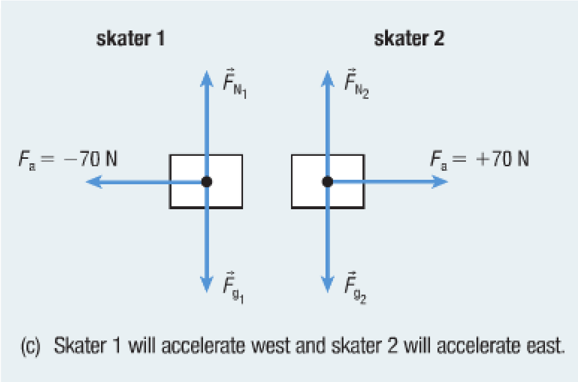
To ensure a fair test in the investigation, it was essential to establish a controlled environment where only the variable of interest is manipulated which in this case was the height. This can be achieved by keeping all other factors constant, such as the angle of the track, and the surface conditions. By maintaining consistency in these variables and conducting multiple trials, minimising confounding factors will obtain reliable data for accurate comparisons and conclusions.

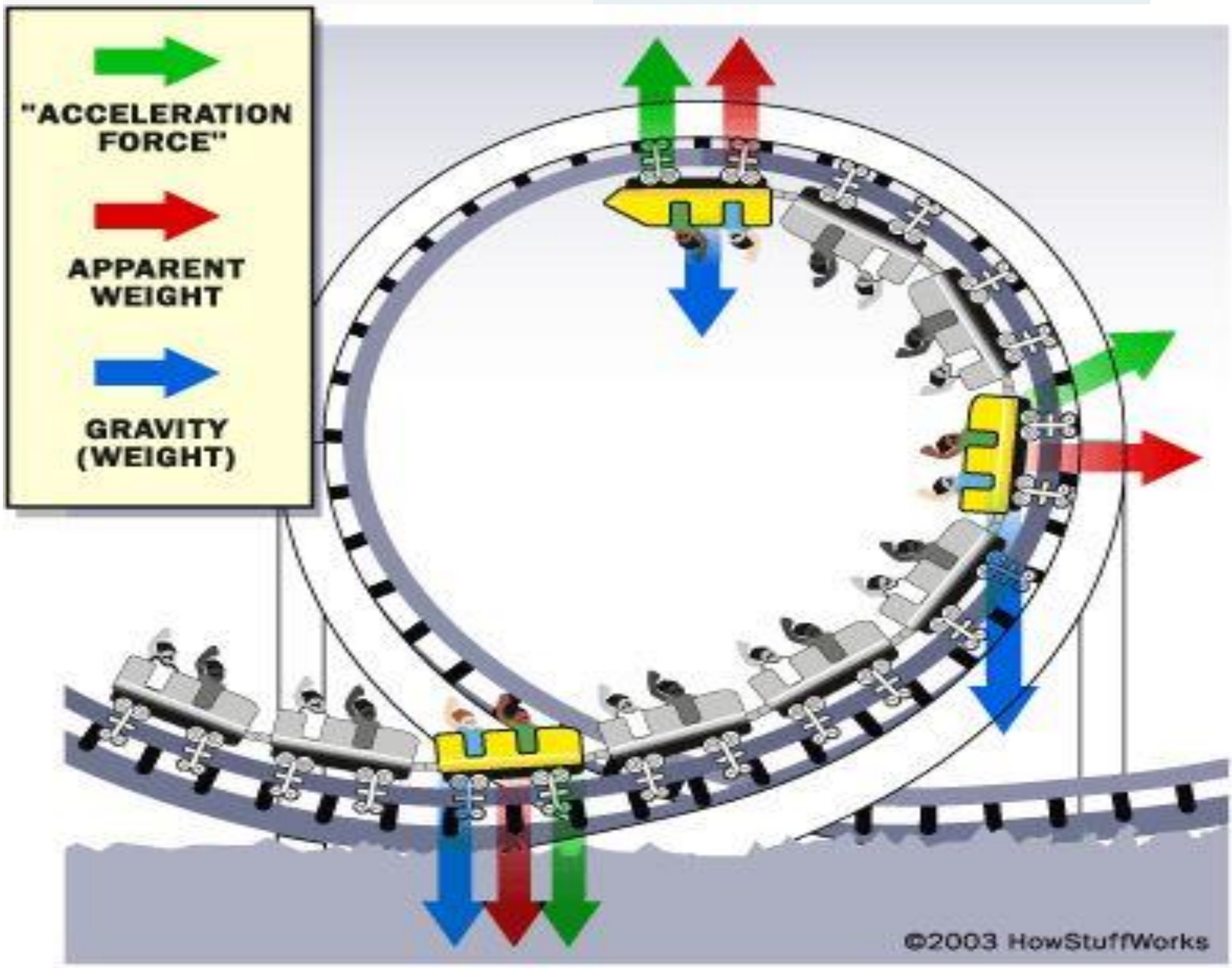
Variables / Independent / Controlled / Dependant

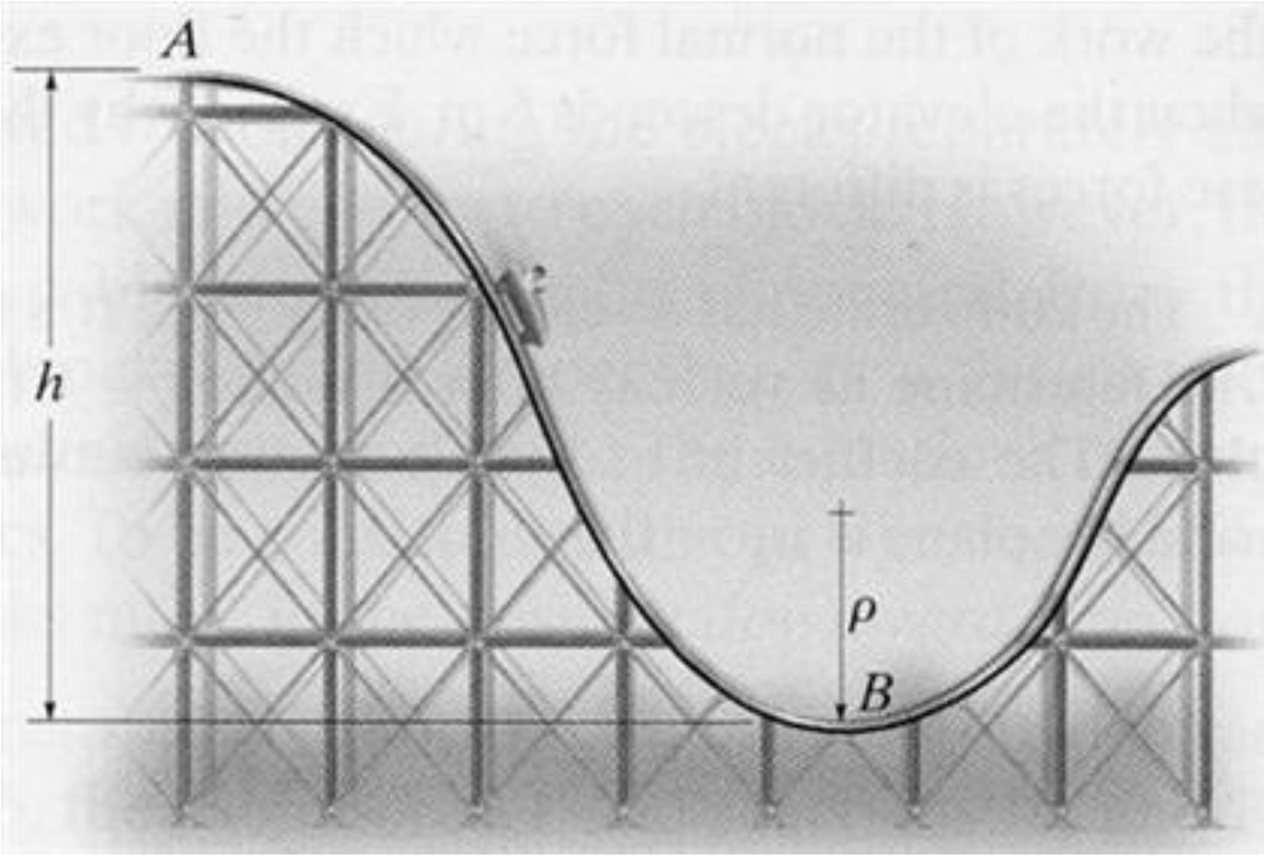
Independent	Dependent variable
Hight of starting point	Speed

Controlled
Surface, marble, track configuration, environmental conditions, timing device, observer consistency









Equipment and Materials:

1. Design and plan the marble run: Decide on the layout and design of your roller coaster. Sketch out the track, including loops, hills, and curves. Consider the dimensions and shape of the track segments.

2. Gather the materials: Collect the necessary materials mentioned, ensuring there is a safe enough cardboard or foam pipe to construct the marble run.

3. Prepare the track segments: Measure and cut the cardboard or foam pipe into the desired track segments. Use a utility knife to ensure that the cardboard or foam pipe is safely cut. Use a ruler or measuring tape to ensure the segments are the correct length and width. Consider using different lengths and shapes for variety.

4. Assemble the track: Begin by attaching the starting point of the marble run to a table. This can be a ramp or an inclined plane. Secure it in place using masking tape or hot glue. Continue attaching the rest of the track segments according to the design, making sure they are securely connected and aligned.

5. Test and adjust: Once the track is assembled, test it with a marble. Release the marble from the starting point and observe its motion along the track. Make adjustments as necessary, such as modifying the track angles or adding supports to ensure the marble follows the desired path.

6. Add loops and other features: If the design includes loops or other special features, create them using curved segments or carefully shaped cardboard or foam pipe. Secure them in place, ensuring the track is smooth and continuous throughout.

7. Decorate and reinforce: If desired, decorate the roller coaster using paint, markers, stickers, or other decorative materials. This can add a visually appealing element to your creation. Additionally, reinforce any weak points or joints with additional tape or glue to improve the structural integrity. Make sure to add a cup on the end of the rollercoaster so the marble doesn't roll away.

8. Test and iterate: Once the roller coaster are complete, use a stopwatch and test it multiple times with marbles to ensure its functionality and stability. Make any necessary adjustments or modifications to improve the performance and smoothness of the marble's motion.

- Foam pipe insulation
- Marble
- Utility knife
- Masking tape
- Ruler
- Table
- Stopwatch


foam isolation pipe


marble


utility knife

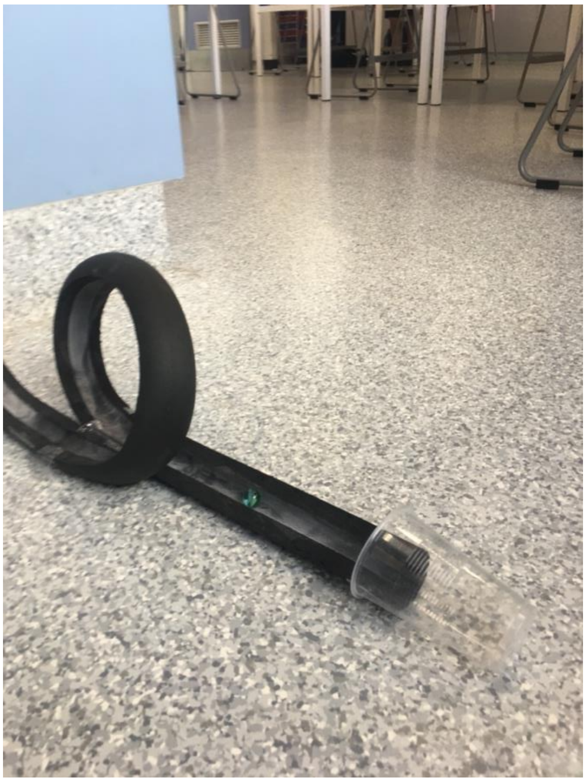

masking tape

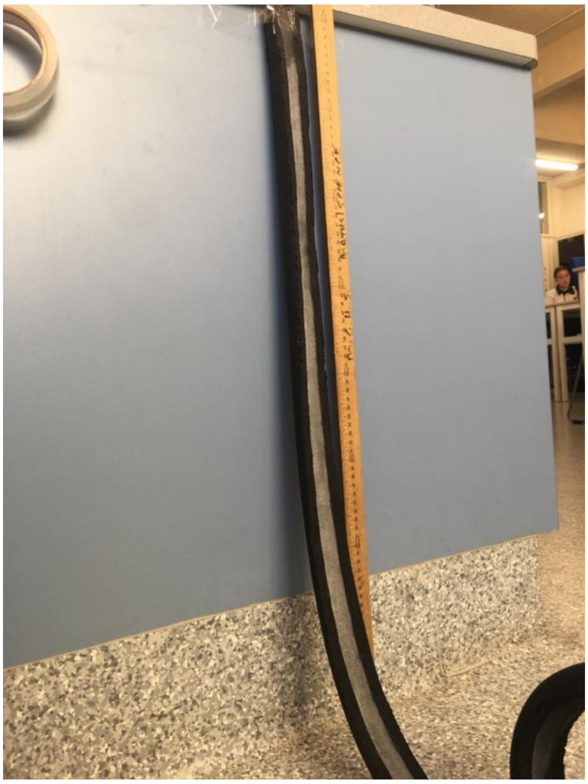

ruler

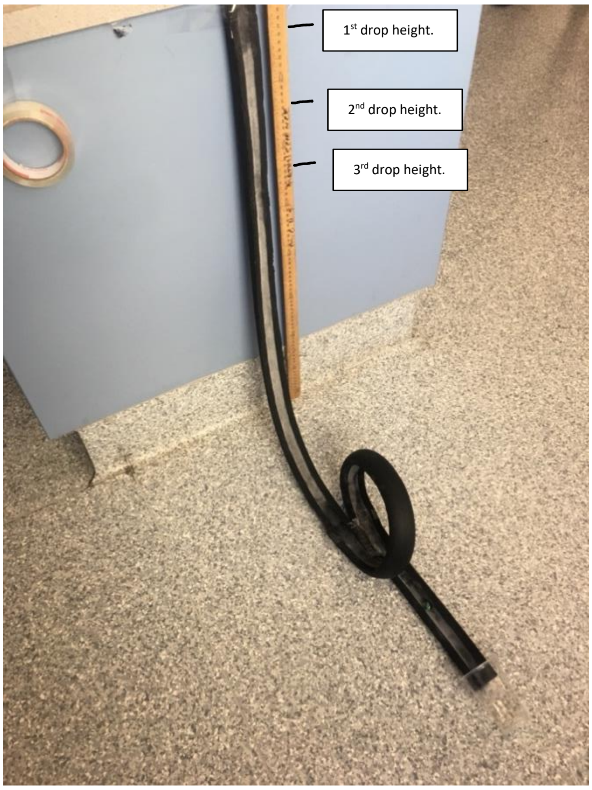

table


stopwatch

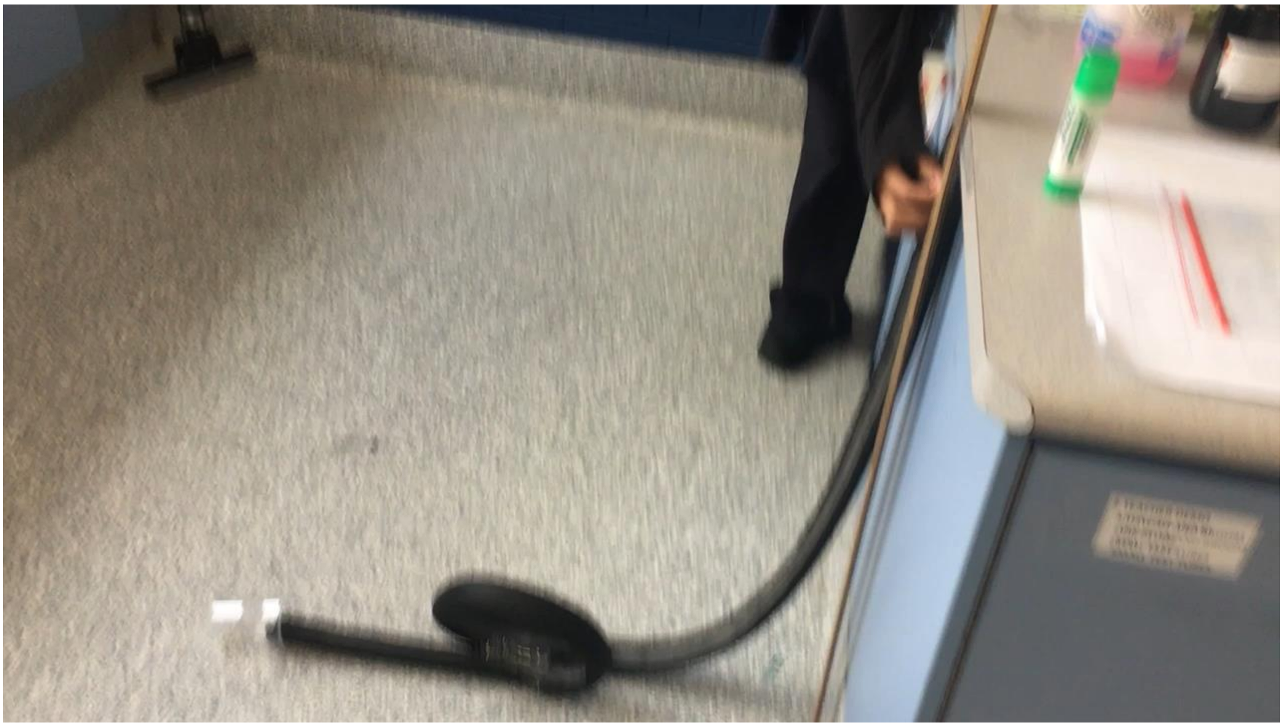






These photos demonstrate the proof of the investigation. The photos also show the angle of the drop, the drop heights the loop, the marble, and the cup at the end of the marble run.

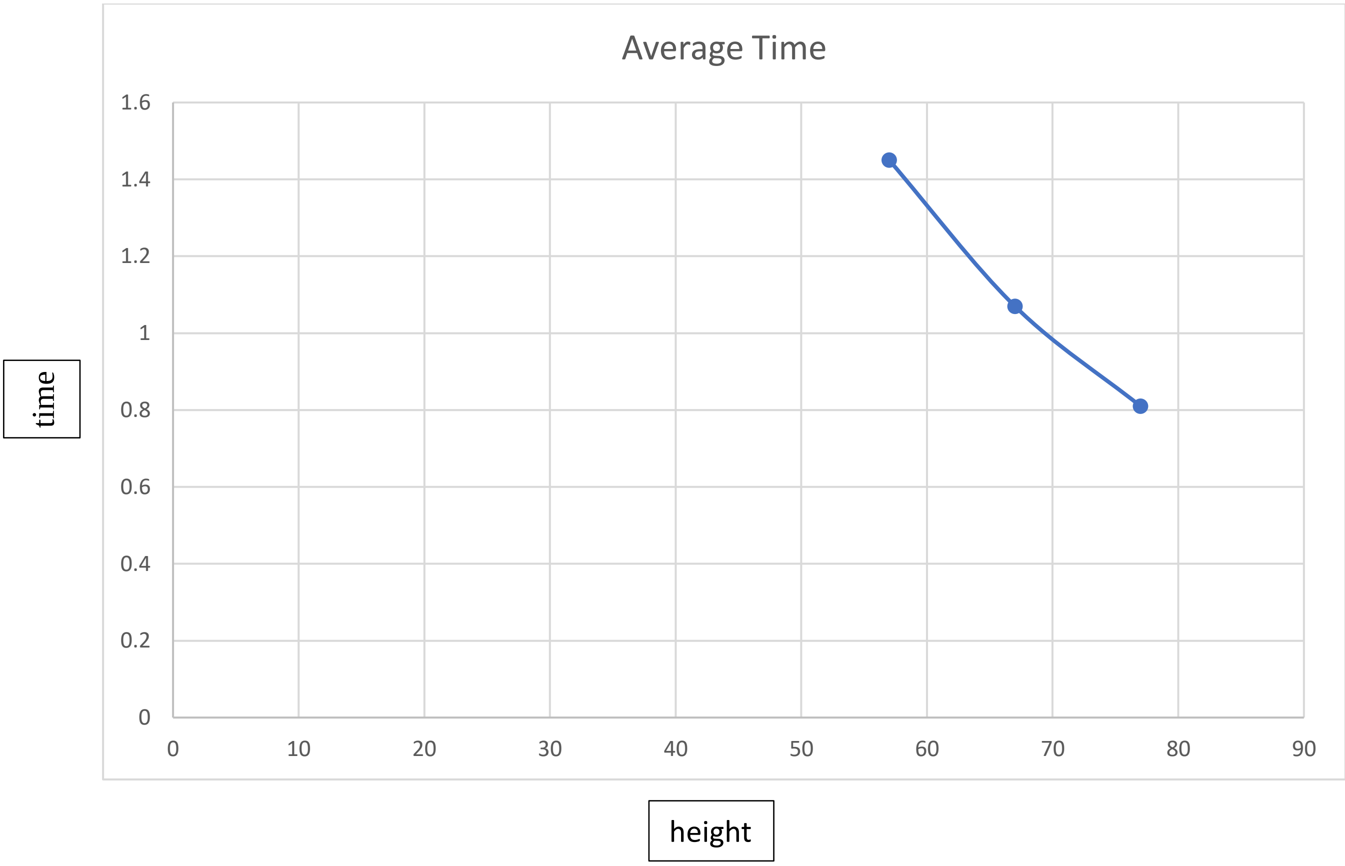


This video shows that several trails had need to be done to figure out what height the marble should be dropped from.

This video demonstrates that the highest point the marble could be dropped from was 77cm.

Results:

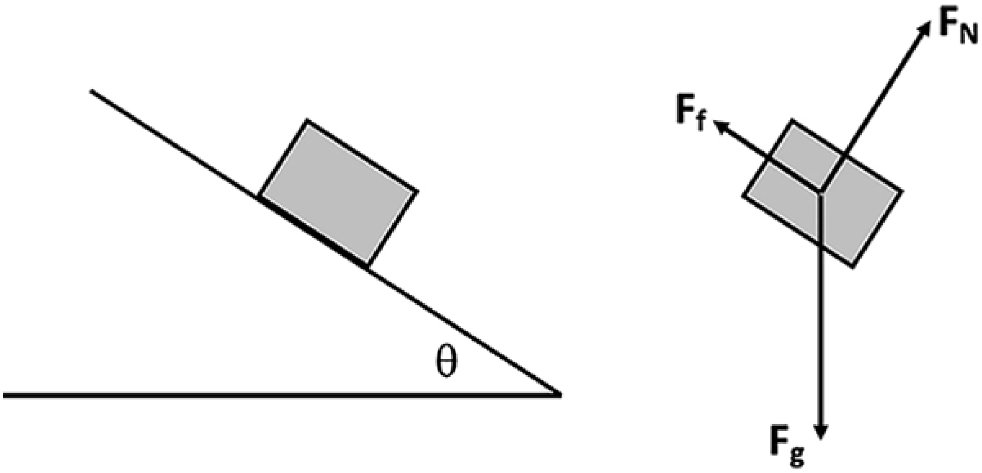
Height (in centimetres):	Trials:	Time (in seconds):	Average (in seconds)	Speed (kilometres per/seconds):	Speed (kilometres per/hour):
77	Trial 1 (for 77cm)	0.85	0.81	2.46	8.88
	Trial 2 (for 77cm)	0.78			
67	Trial 1 (for 67cm)	1.04	1.07	1.86	6.72
	Trial 2 (for 67cm)	1.1			
57	Trial 1 (for 57cm)	1.3	1.45	1.37	4.9
	Trial 2 (for 57cm)	1.6			



Processing and analysing data and information:

Validity:

The graph presented in this study accurately represents the data collected from the marble run practical. The graph illustrates the relationship between the drop height of the marble and the corresponding fall time. The data points are clearly plotted, showing a consistent pattern as the drop height increases. The graph showcases three distinct data sets corresponding to drop heights of 77cm, 67cm, and 57cm. The average fall times for each drop height are 0.81 seconds, 1.07 seconds, and 1.45 seconds, respectively. The plotted points align with the calculated averages, further reinforcing the validity of the graph. The graph's presentation allows for a visual analysis of the data, making it easier to identify any trends or relationships between drop height and fall time.



Precision:

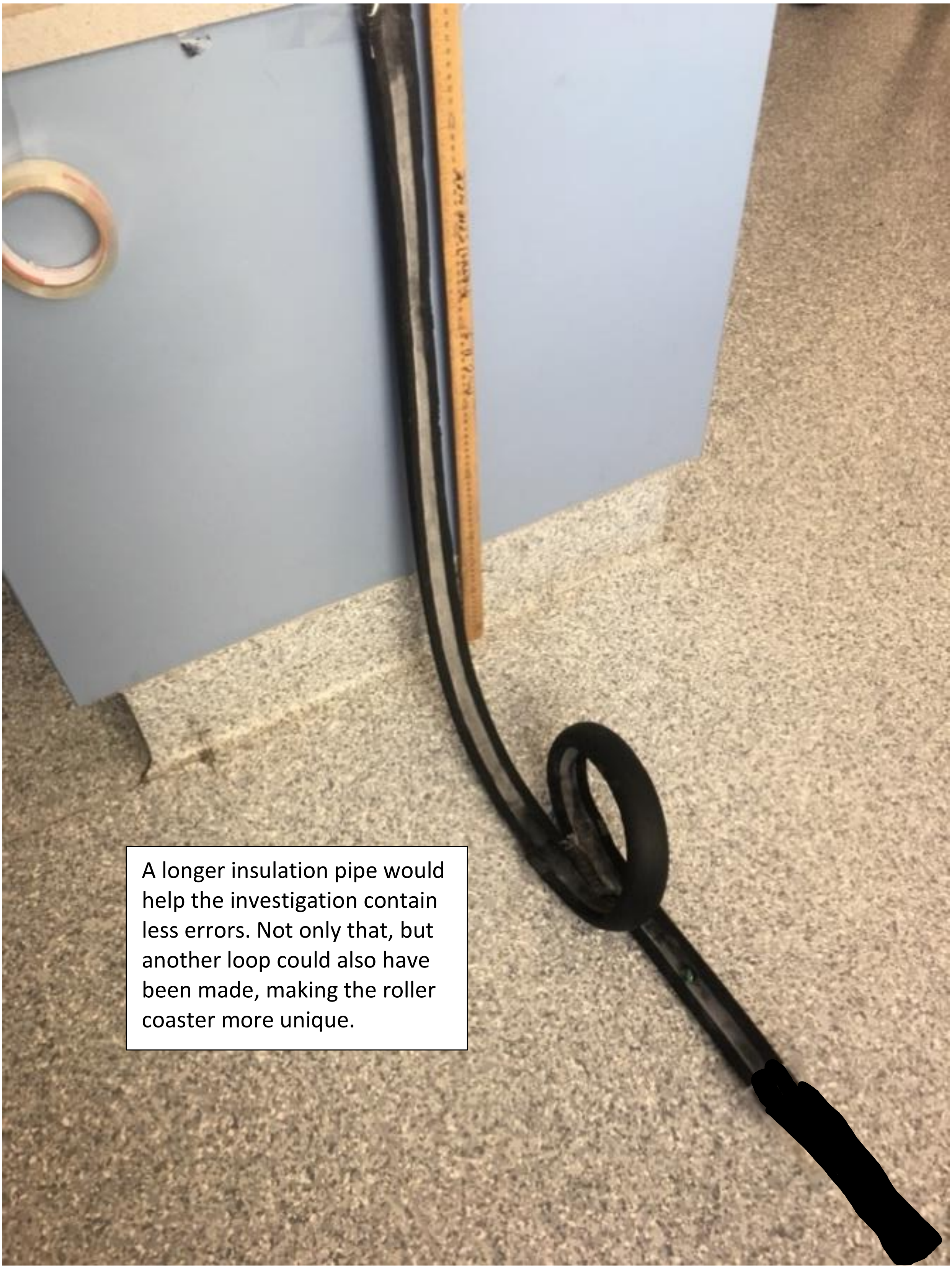
The results recorded in this study demonstrate a high level of precision in the measurements. For each height, two trials were conducted, and the recorded times exhibit consistency and closeness to each other. The average times calculated for each height indicate minimal deviation, reinforcing the precision of the results. This consistency and limited variability in the data points suggest that the experimental procedure was executed accurately and with precision. The precise measurements obtained allow for reliable conclusions to be drawn regarding the relationship between height and time in the marble run investigation. Furthermore, the calculated speeds for each trial show a logical progression as the height increases, providing further support for the precision of the results. Overall, the precision of the measurements enhances the validity of the findings and ensures the reliability of the experimental data collected.

Accuracy:

The accuracy of the results obtained in this study is significant. The measurements for each height were recorded with attention to detail and precision, ensuring the reliability of the data. The experimental procedure was carefully conducted, considering factors that could affect the accuracy of the measurements, such as using precise timing devices and maintaining consistent experimental conditions. The recorded times for each trial reflect the actual fall times of the marble, providing accurate data for analysis. The calculated averages and derived values, such as speed, were obtained through accurate computations based on the recorded measurements. The accuracy of the results enhances the credibility of the findings and allows for meaningful conclusions to be drawn regarding the relationship between height and time in the marble run investigation.

Errors:

During the marble run experiment, a problem occurred due to the lacking length of the foam pipe insulation. The shorter length of the foam pipe insulation delayed the marble's ability to maintain a consistent and stable curve throughout the track. As a result, the marble failed to complete certain sections of the roller coaster. This issue disrupted the intended flow of the experiment, making it difficult to measure and analyse the marble's performance accurately. Additionally, the inadequate length of the foam pipe insulation limited the variety of design elements and challenges that could be incorporated into the roller coaster, reducing the experiment's overall complexity and potential for innovative exploration. To address this problem in future experiments, it is crucial to ensure that the length of the foam pipe insulation matches the desired track layout, allowing the marble to cover the entire track smoothly.



A longer insulation pipe would help the investigation contain less errors. Not only that, but another loop could also have been made, making the roller coaster more unique.

Dimensions

	Width	Height	Length
Product	13mm	1000mm	9mm
Package	40mm	40mm	1000mm

Patterns:

Several patterns can be discerned from the collected data. Firstly, as the drop height increases, there is a clear trend of the fall time also increasing. This indicates that a greater height results in a longer time for the marble to complete its descent along the track. Additionally, examining the calculated averages for each height reveals a gradual increase in fall time with decreasing speed. This pattern suggests that as the marble travels a shorter distance along the track, it experiences less time to reach the bottom because of less potential and kinetic energy. Furthermore, it is important that the difference between the fall times of Trial 1 and Trial 2 for each height is relatively small, indicating consistency and reproducibility in the measurements.

Was the hypothesis supported?

The results obtained in this investigation strongly support the hypothesis that increasing the height of the starting point in a marble roller coaster leads to faster speeds and longer distances travelled by the marble, aligning with the principles of kinetic and potential energy observed in real-life roller coasters. As the drop height increased, there was a clear development of longer fall times and higher average speeds. The data consistently demonstrated that marbles released from greater heights experienced longer durations of descent and covered larger distances along the roller coaster track. These findings indicate that the marbles gained more potential energy from the increased height, which was then converted into kinetic energy as they descended, resulting in higher speeds and greater distances travelled. Therefore, the results support the notion that manipulating the starting height influences the marble's energy transformations, closely resembling the principles observed in real-life roller coasters.

Evaluating

How could the investigation be improved?

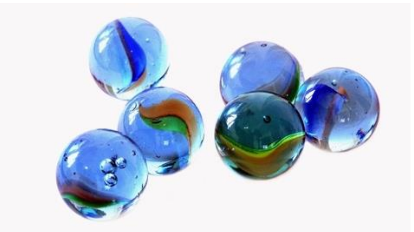
The investigation could be improved by making some key improvements can be implemented. First, increasing the number of trials for each drop height would provide a larger sample size and reduce the impact of errors, leading to more reliable results. Second, ensuring consistent and precise measurements by using advanced timing devices and precise measuring tools would minimize measurement errors and improve the accuracy of the data.

How could these findings be useful to others?

The findings can be useful to others, particularly in science education. It demonstrates the relationship between the height of the starting point in a marble roller coaster and the resulting speed and distance travelled, the findings can serve as a valuable educational tool. Teachers can utilize the investigation as an activity to engage students in learning about energy transformations, physics principles, and the scientific method. The findings provide an example that can help students comprehend concepts such as kinetic and potential energy, as well as understand the practical application of these principles in real-life scenarios like roller coasters.

Related questions

Several related questions that pertain to your topic of the relationship between the height of the starting point in a marble roller coaster and its impact on speed and distance travelled include: Can different types of marbles result in varying performance on the roller coaster? How does the inclusion of different track materials affect the marble's motion and overall performance? How does Newton's third law relate to this topic? All these questions can be investigated and researched about as it relates to the topic that has been investigated.





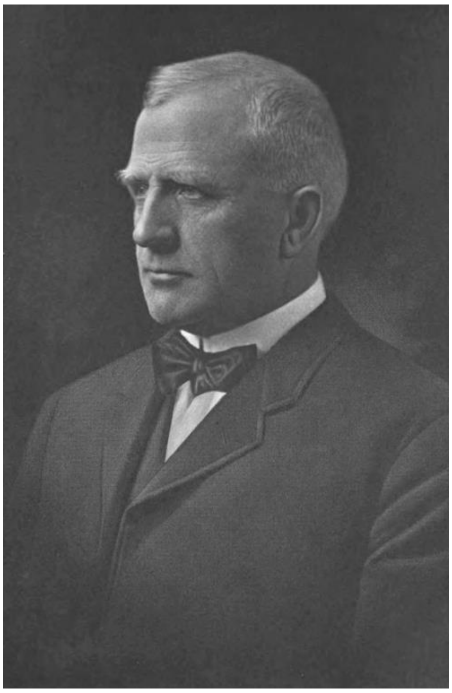

Conclusion

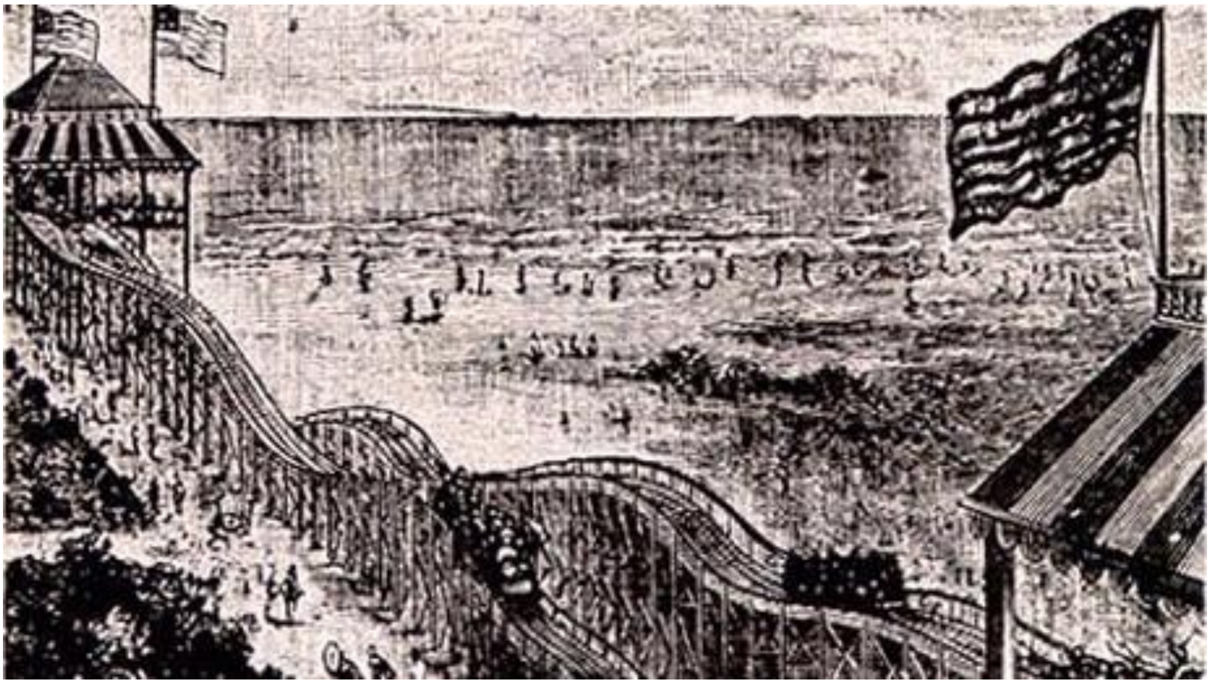
The conclusion that can be drawn is that the experimental investigation successfully demonstrates a consistent and reliable relationship between the height of the starting point in a marble run and the resulting speed and distance travelled by the marble. The data obtained shows a clear pattern of longer fall times and higher speeds as the drop height increases. These findings support the hypothesis that increasing the height leads to faster speeds and longer distances, reflecting the principles of kinetic and potential energy observed in real-life roller coasters. The measurements contribute to the conclusion, highlighting the significance of the experimental factors in influencing the marble's performance along the track.

Research

Roller coasters were invented by LaMarcus Adna Thompson in 1884 as thrilling amusement rides. They quickly gained popularity, offering a unique and exhilarating experience of speed, drops, and G-forces in a controlled environment. Roller coasters became symbols of the amusement park industry, attracting large crowds and providing entertainment. Over time, roller coaster designs and technologies have evolved, allowing for the development of faster, taller, and more thrilling coasters. Today, roller coasters come in various forms, serving as both sources of entertainment and platforms for scientific research on concepts such as gravity, acceleration, and energy transformation.

Roller coasters operate based on the conversion of potential energy into kinetic energy as the coaster descends from a higher point, utilizing various track elements to control speed, direction, and forces experienced by riders. Similarly, a marble roller coaster mimics these principles on a smaller scale, with the marble representing the coaster. As the marble rolls down the track, gravitational potential energy is converted into kinetic energy, and track design elements manipulate the marble's speed and direction. While not identical to real roller coasters, a marble roller coaster provides a simplified representation of how energy transformations and track configurations influence motion, allowing for exploration and understanding of the underlying principles.





Logbook is a separate document.
Risk assessment for Scientific Inquiry is a separate document.
Word Count (not including textboxes, tables, or headings): 2189.
Assistance: School teachers.

This Month in physics history (no date) *American Physical Society*. Available at: https://www.aps.org/publications/apsnews/200401/roller-coaster.cfm#:~:text=January%201884%3A%20First%20U.S.%20Patent,more%20than%20just%20mere%20entertainment. (Accessed: 11 June 2023).

Published by Statista Research Department and 28, F. (2023) *Oldest roller coasters worldwide 2023*, *Statista*. Available at: https://www.statista.com/statistics/1368664/oldest-roller-coasters-worldwide/#:~:text=As%20of%20January%202023%2C%20the,in%201912%20in%20Melbourne%2C%20Australia. (Accessed: 11 June 2023).

Health, B. (2016) *Seeking thrills on National Roller Coaster Day*, *Beaumont Health*. Available at: https://www.beaumont.org/health-wellness/blogs/seeking-thrills-on-

national-roller-coaster-day#:~:text=Our%20fight%20or%20flight%20response,the%20psychological%20effect%20is%20positive. (Accessed: 11 June 2023).

(No date b) *Potential and kinetic energy*. Available at: http://www.csun.edu/~psk17793/S9CP/S9%20potential_and_kinetic_energy.htm#:~:text=Kinetic%20and%20Potential%20Energy%3A&text=Energy%20stored%20in%20an%20object,its%20motion%20is%20Kinetic%20Energy. (Accessed: 11 June 2023).

(No date a) *ABC News*. Available at: https://abcnews.go.com/GMA/story?id=125989&page=1#:~:text=The%20rides%20increase%20blood%20pressure,should%20also%20avoid%20the%20rides. (Accessed: 11 June 2023).

Friction and resistance (no date) *TheSchoolRun*. Available at: https://www.theschoolrun.com/homework-help/friction-and-resistance#:~:text=The%20amount%20of%20friction%20depends,would%20on%20a%20wooden%20floor. (Accessed: 14 June 2023).

What is Newton's third law? (article) (no date) *Khan Academy*. Available at: https://www.khanacademy.org/science/physics/forces-newtons-laws/newtons-laws-of-motion/a/what-is-newtons-third-law (Accessed: 14 June 2023).

for [redacted]

OSA RISK ASSESSMENT FORM

for all entries in (✓) ☐ Models & Inventions and ☑ Scientific Inquiry

This must be included with your report, log book or entry. One form per entry.

STUDENT(S) NAME: Raisa Afsara ID: 0380-028

SCHOOL: mitcham Girls High School.

Activity: Give a brief outline of what you are planning to do.

Explaining how a roller coaster works could be demonstrated by making a miniature replica of a roller coaster. A unique name for a version of a roller coaster is Marble Run. Using a soft, bendable material replicates a real life roller-coaster. Potential and Kinetic energy must be investigated.

Are there possible risks? Consider the following:

- Chemical risks: Are you using chemicals? If so, check with your teacher that any chemicals to be used are on the approved list for schools. Check the safety requirements for their use, such as eye protection and eyewash facilities, availability of running water, use of gloves, a well-ventilated area or fume cupboard.
- Thermal risks: Are you heating things? Could you be burnt?
- Biological risks: Are you working with micro-organisms such as mould and bacteria?
- Sharps risks: Are you cutting things, and is there a risk of injury from sharp objects?
- Electrical risks: Are you using mains (240 volt) electricity? How will you make sure that this is safe? Could you use a battery instead?
- Radiation risks: Does your entry use potentially harmful radiation such as UV or lasers?
- Other hazards.

Also, if you are using other people as subjects in an investigation you must get them to sign a note consenting to be part of your experiment.

Risks	How I will control/manage the risk
- sharp utility knife - cutting tape.	- the risk will be managed by ensuring that there is a responsible adult near by confirming that cutting an item is done safely without causing any harm.

(Attach another sheet if needed.)

Risk Assessment indicates that this activity can be safely carried out

RISK ASSESSMENT COMPLETED BY (student name(s)): Raisa Afsara

Raisa.

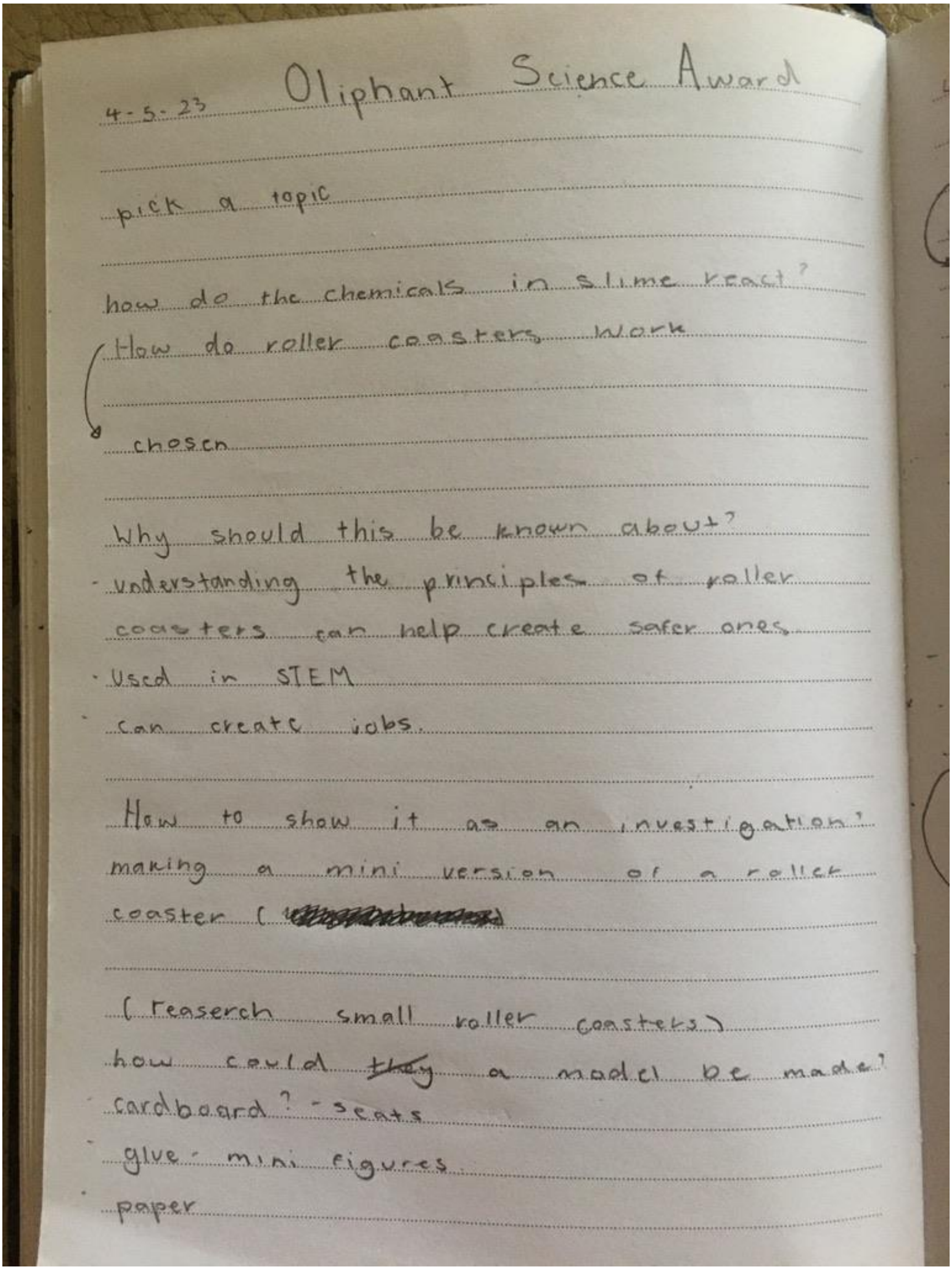
SIGNATURE(S):

☐ By ticking this box, I/we state that my/our project adheres to the listed criteria for this Category.

TEACHER'S NAME: LUKE WILSON

SIGNATURE: [signature] DATE: 19/06/23

Logbook



4-5-23 Oliphant Science Award

pick a topic

how do the chemicals in slime react?
How do roller coasters work

chosen

Why should this be known about?
- understanding the principles of roller coasters can help create safer ones
- Used in STEM
- can create jobs.

How to show it as an investigation?
making a mini version of a roller coaster ([illegible])

(reaserch small roller coasters)
how could ~~they~~ a model be made?
- cardboard? - seats
- glue - mini figures
- paper

4-5-23

a material with curves can be used as the coaster.

cheap!!

foam ~~to~~ ~~insulation~~ insulation pipe (bunnings) $6.50

(cut to see the seats fall

marble could be used as seats

make unique name for the design

- small roller coaster
- mini model
- marble run
- roller coaster

chosen

materials - to create

insulation pipe

marble

tape

7-5-23

(create the marble run)

did the marble run work?
yes.
What was added into it to make it interesting?
a loop.

the highest height it was dropped from was 78 cm
the lowest was 38 cm
why?
this was because there was less potential energy which then converted into kinetic energy
not enough speed or centripental force

(write about forces in the inquiry.)

results from timing the drop time and measuring the ~~hight~~ height.

7-5-23

77 cm
trial 1 - 0.85
trial 2 - 0.78

67 cm
trial 1 - 1.04
trial 2 1.1

57 cm
trial 1 - 1.3
trial 2 - 1.6

calculate average
find the Km per second
find the km per hour

14.5-23

reaserch questions

Create some questions that relate to your topic and reaserch about them. (one paragraph each)

how does the height of the starting point affect the speed and distance travelled by the marble?

The height of the starting point affects the speed and distance travelled by the marble. The marble starts off with potential energy, the higher the starting point is the more potential energy it has. As soon as the marble is let go the potential energy converts into kinetic energy (the energy of motion) when the marble is rolling, the potential energy decreases as the kinetic energy increaces. The distance is affected because the higher the marble is, the more potential energy that is stored which then transfers into kinetic energy.

16-5-23

Can different types of marbles result in varying performances in the marble run?

Different types of marbles can result in varying performances on the marble run. Glass, plastic, metal are examples of marbles. Each type of marble has a different mass. Metal marbles generally have a larger mass meaning it will fall faster because it reaches a higher velocity. If all the marbles are dropped from the same height, they will have the same potential energy. While the potential energy converts into kinetic energy, the metal ball will gain more speed. This is because the metal ball is denser and heavier, meaning that it has more mass. Similar to the potential energy, all marbles will have the same gravitational force so the marbles will experiance the same acceleration due to gravity, however, since the masses are different the metal ball will feel a stronger gravitational pull.

22.5.23

how does the inclusion of different track materials affect the marbles motion and overall performance?

The inclusion of different track materials, such as wood plastic and metal, in a marble run experiment significantly impacts the marble's motion and overall performance, particularly trough the influence of friction. Friction plays a crucial role in determining the speed, stability and control of the marble as it travels along the track. Wood, with its rougher texture, tends to introduce more friction, causing the marble to experience a slower and more controlled decent. Plastic tracks, on the other hand, offer a smoother surface, resulting in reduced friction and potentially faster speeds for the marble. Metal tracks, known for their low friction properties, minimize resistance, allowing the marble to glide smoothly and maintain momentum. By varying the track materials, one can observe how friction affects the marble's acceleration, energy loss, and overall momentum.

1-6-23

How does Newtons third law relate to this topic?

Newton's third law of motion is fundamental to understand how forces operate in a marble run According to this law, every action has an equal and opposite reaction. In the context of the roller coaster, this means that as the marble moves along the track, it exerts a force on the track, and in turn, the track applies an equal force back on the marble For example, when the marble goes down a slope, gravity pulls it downward, causing the marble to push against the track with a force. As a result, the track pushes back on the marble and the track is what keeps the marble on the track, allows it to move through loops, and experience different accelerations

2-6-23

How did reaserching these questions help the investigation?

Reaserching about these questions helped me gain greater knowledge on this topic which helped with writing the Inquiry.

(finish the inquiry and don't forget to write about 'fair test')

4-5-23 Oliphant Science Award

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