Force and motion

Portfolio summary

In this portfolio, the student shows understanding of the factors that impact on the motion of a model car and of the mechanical forces acting on it. They use knowledge of material properties to improve performance. Students describe Newton’s Second Law of Motion, demonstrate understanding of the concept of energy and can justify changes to the design in scientific and engineering terms. They evaluate experimental method, identify reasons for errors and can draw a correct conclusion about their method.

Students outline the design brief and suggest changes to their model to meet the criteria. They justify and make changes to the model, test their changes and record the results.

Students recognise the impact of angles on axle function. They collect data and represent it in a table and segmented line graph. They calculate average speed.

This portfolio has its basis in Science and Technologies, particularly engineering principles. Mathematics plays a minor role.

Report: Mouse trap dragster redesign

Sample summary

This task was part of a unit of work designed to investigate forces and laws of motion. Students participated in a series of lessons covering Newton’s Laws of Motion, forces and simple machines. Teachers provided students with skills in research and scientific report writing; graphing; and speed, distance and time calculations so that they were able to work independently on the task.

Students were given a mouse trap dragster and asked to describe its existing features. They were then given a design brief that required them to modify the dragster so that it either travelled as fast or as far as possible. They needed to test their design, record results and draw a conclusion based on those results.

Achievement Standards

Technologies

Mathematics

Design and Technologies

By the end of Year 10, students explain how people working in design and technologies occupations consider factors that impact on design decisions and the technologies used to produce products, services and environments. They identify the changes necessary to designed solutions to realise preferred futures they have described. When producing designed solutions for identified needs or opportunities, students evaluate the features of technologies and their appropriateness for purpose for one or more of the technologies contexts.

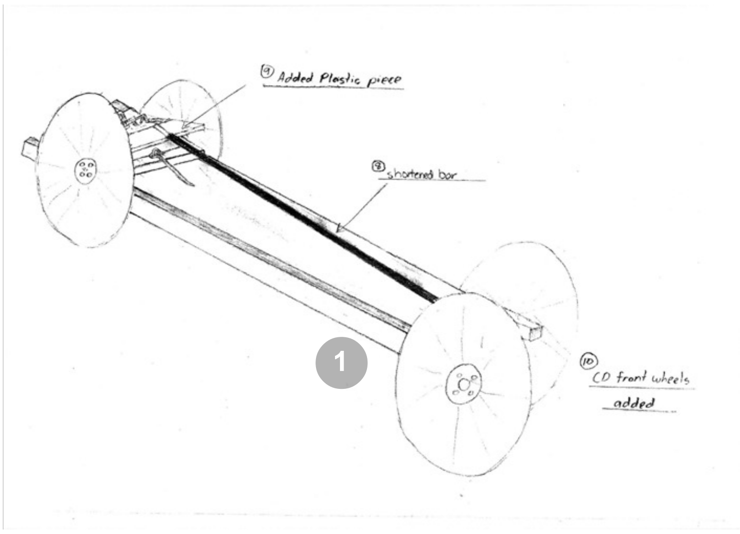
Students create designed solutions for one or more of the technologies contexts based on a critical evaluation of needs or opportunities. They establish detailed criteria for success, including sustainability considerations, and use these to evaluate their ideas and designed solutions and processes. They create and connect design ideas and processes of increasing complexity and justify decisions. Students communicate and document projects, including marketing for a range of audiences. They independently and collaboratively apply sequenced production and management plans when producing designed solutions, making adjustments to plans when necessary. They select and use appropriate technologies skilfully and safely to produce high-quality designed solutions suitable for the intended purpose.

Digital Technologies

By the end of Year 10, students explain the control and management of networked digital systems and the security implications of the interaction between hardware, software and users. They explain simple data compression, and why content data are separated from presentation.

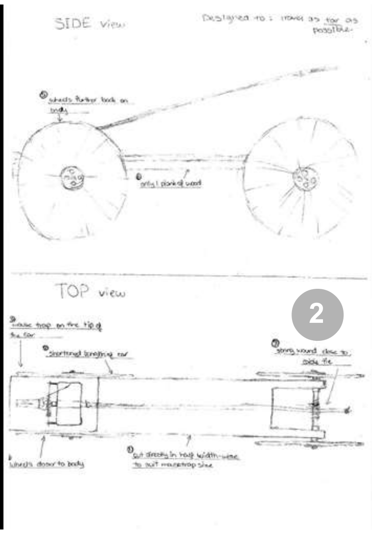
Students plan and manage digital projects using an iterative approach. They define and decompose complex problems in terms of functional and non-functional requirements. Students design and evaluate user experiences and algorithms. They design and implement modular programs, including an object-oriented program, using algorithms and data structures involving modular functions that reflect the relationships of real-world data and data entities. They take account of privacy and security requirements when selecting and validating data. Students test and predict results and implement digital solutions. They evaluate information systems and their solutions in terms of risk, sustainability and potential for innovation and enterprise. They share and collaborate online, establishing protocols for the use, transmission and maintenance of data and projects.

Report



Annotations

1 **Technologies**
Illustrates changes to improve original design



Annotations

1 Technologies
Suggests changes to design to fit the design brief

2 Technologies
Justifies further changes to meet design brief

①

SKETCH & DESIGN BRIEF

Our mousetrap car is designed to: Travel as FAR as possible

It was required of us to take the original mouse trap car and modify it to either: travel as fast as possible, travel as far as possible, or consistently travel a predicted distance. On top of that, we had to make the car fit into a box that was smaller than the original car.

In order for our car to suit these conditions but still be good, my partner and I made the following modifications:

① Cut directly in half width-wise to suit mousetrap size: By cutting the wooden plank we have lost a lot of the cars unnecessary weight and have given the car a slimmer build to glide through the air, along with the fact we needed to fit in the box.

② Shortened length of car: We noticed that we didn't need all that extra length so we shortened the car enough for everything to still be functional and still fit in the box.

③ Mousetrap on the tip of the car: We wanted the mousetrap to be as far away from the back wheels as possible, but under the circumstances that we needed the car as small as possible we put it at the very tip of the car.

④ Wheels closer to body: By having the wheels flush against the car without it touching the cars sleek build is enhanced.

⑤ Wheels further back on body: To go with the criteria of fitting the car into the box we made sure that the car was still balanced, then moved the wheels back to keep the balance and weight.

⑥ Only 1 plank of wood: To make the car more aerodynamic and lighter in weight.

⑦ String wound close to cable tie: So the string doesn't get caught on the straws, we wind the car up making sure it's in the middle.

Annotations

1 Science
Identifies the weight, size and air resistance of the car as key properties affecting travel distance and makes appropriate improvements

2 Technologies
Justifies a design change with the need for balance

②

SKETCH & DESIGN BRIEF

⑧ Shortened bar to create a larger lever/pulley angle. By enlarging this angle, the correct directional pulling force could be applied to the axle and ultimately improved its performance

⑨ Added plastic piece for a more stable lever attachment. This ensures the mousetrap pieces do not experience uneven amounts of pressure

⑩ CD back wheels added for better support and less friction. This allows the car to travel smoother and stops the lever from touching the ground

Annotations

1 Science
Demonstrates understanding of the mechanical forces acting on the car

2 Science
Uses knowledge of material properties to improve the performance of the car

Mouse-Trap Car—Elements of Motion

Friction

Friction occurs every time two objects rub together. It is the force that stops an object in motion such as a rolling ball or a book sliding across a desk. Many things can reduce friction and lessen the effects. Things like water or ice on a road give a person less control over their vehicle, for example, because friction has been reduced, the force that keeps the tires of a car gripping to the road.

Different surfaces have different levels of friction. Rough materials, like sandpaper, will stop an object's motion much faster than an object sliding on ice.

'Friction is a force that always opposes motion.' (Excel Preliminary Physics—Neville Warren, p. 112). Our goal was to have our mousetrap car stay in motion for as long as possible, so it was very important that friction was reduced as much as our materials allowed. Whenever we tested our mouse-trap car, we ensured we used flat, smooth surfaces, such as that of the school hall. We used CDs for all four of our wheels, thin and smooth for easy rolling, and we encased our axle in a plastic straw to allow it to rotate effortlessly.

Simple Machines

The construction of our mouse-trap car involved several simple machines: an axle, screws, a lever and a pulley. The axle in our current car model has been shortened, allowing the wheels to be attached closer towards the body. This ensures the car has a more compact size, a part of the construction criteria. In addition, the change helps give the car a sleeker build, helping to reduce air resistance.

We used eyelet screws to attach our axle to the car and apart from a few minor positioning changes, we did not alter the use of screws from the original design.

The lever on our mouse-trap car is in the form of a thin pole. One end is attached to the mouse-trap and the other end is connected to fishing wire. As the lever is pulled in an arching motion by the mouse-trap springs, the wire attached to it (the pulley) turns the axle.

In the original car design, when the lever was pulled down, an acute angle in the pole and wire was created and the car would not travel. This was because it did not provide the directional force needed to turn the axle. When we shortened the lever, creating an obtuse angle, the meeting point of the lever and pulley was in front of the axle, allowing the pole to pull the wire in the correct direction.

Annotations

1. **Science**
Describes the phenomenon of friction as a physical force and explains its relationship to motion

2. **Science**
Identifies friction as the key phenomenon to consider in the given task

3. **Science**
Describes the function of the key components of the car, how they have been changed and gives justification for the alterations based on reasoning

4. **Mathematics**
Recognises the differences between acute and obtuse angles and the impact the angle has on the function of the axle

Newton's Second Law

As stated in Newton's Second Law, the relation of force(F), mass(m) and acceleration(a) is: F=ma. We had to ensure that our mouse-trap car required as little force as possible to travel. To achieve this, we lessened its mass by using less layers of wood, and narrowing its width. We did, however elongate our car as much as possible so that our lever had a greater distance to travel, creating slow-release energy and ultimately, allowing our car to travel further.

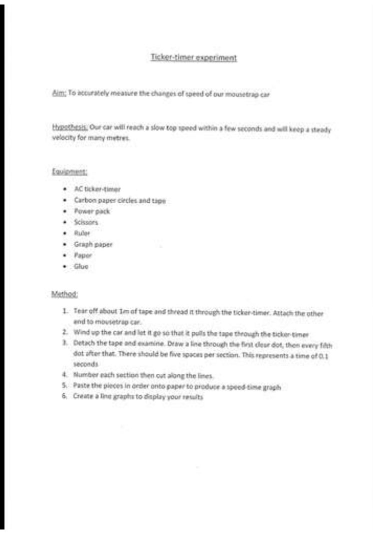
Bibliography:

- Warren, N. G. Excel Preliminary Physics. Glebe, NSW: Pascal, 2000. Print.
- "MIKIDS for YOUR KIDS!" MIKIDS for YOUR KIDS! Accessed May 31, 2015. http://www.mikids.com/Smachines.htm.
- "Newton's 3 Laws of Motion." Newton's 3 Laws of Motion. Accessed May 30, 2015. http://teachertech.rice.edu/Participants/louviere/Newton/law2.html.

Annotations

1. **Science**
Describes Newton's Second Law of Motion and how it applies to the given problem

2. **Science**
Demonstrates understanding of the concept of energy



Ticker-timer experiment

Aim: To accurately measure the changes of speed of our mousetrap car

Hypothesis: Our car will reach a slow top speed within a few seconds and will keep a steady velocity for many metres.

Equipment:

- AC ticker-timer
- Carbon paper circles and tape
- Power pack
- Scissors
- Ruler
- Graph paper
- Paper
- Glue

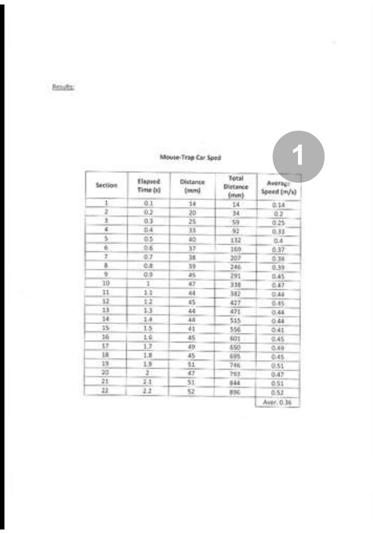
Method:

1. Tear off about 1m of tape and thread it through the ticker-timer. Attach the other end to mousetrap car.
2. Wind up the car and let it go so that it pulls the tape through the ticker-timer
3. Detach the tape and examine. Draw a line through the first clear dot, then every fifth dot after that. There should be five spaces per section. This represents a time of 0.1 seconds
4. Number each section then cut along the lines.
5. Paste the pieces in order onto paper to produce a speed-time graph
6. Create a line graphs to display your results

Annotations

1 **Science**
Suggests a plausible hypothesis based on the reasoning demonstrated in the design phase

2 **Science**
Gives logical sequence of steps that describe the method of measurement



Results:

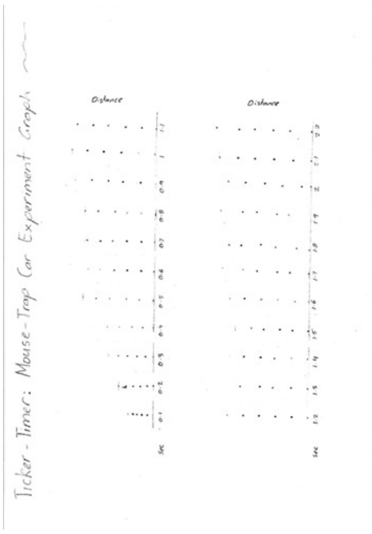
Mouse-Trap Car Spod

Section	Elapsed Time (s)	Distance (mm)	Total Distance (mm)	Average Speed (m/s)
1	0.1	14	14	0.14
2	0.2	20	34	0.2
3	0.3	25	59	0.25
4	0.4	33	92	0.33
5	0.5	40	132	0.4
6	0.6	37	169	0.37
7	0.7	38	207	0.38
8	0.8	39	246	0.39
9	0.9	45	291	0.45
10	1	47	338	0.47
11	1.1	44	382	0.44
12	1.2	45	427	0.45
13	1.3	44	471	0.44
14	1.4	44	515	0.44
15	1.5	41	556	0.41
16	1.6	45	601	0.45
17	1.7	49	650	0.49
18	1.8	45	695	0.45
19	1.9	51	746	0.51
20	2	47	793	0.47
21	2.1	51	844	0.51
22	2.2	52	896	0.52
				Aver. 0.36

Annotations

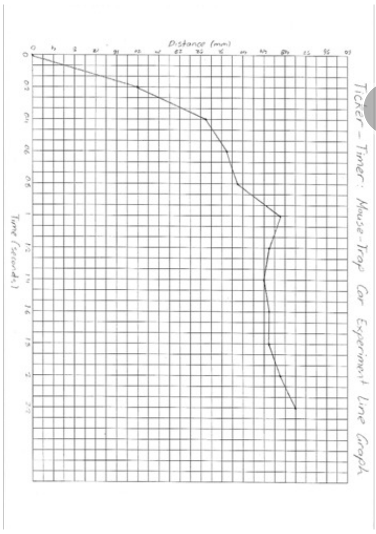
1 **Mathematics**
Collects and presents data in a table

2 **Mathematics**
Calculates average speed from the data collected



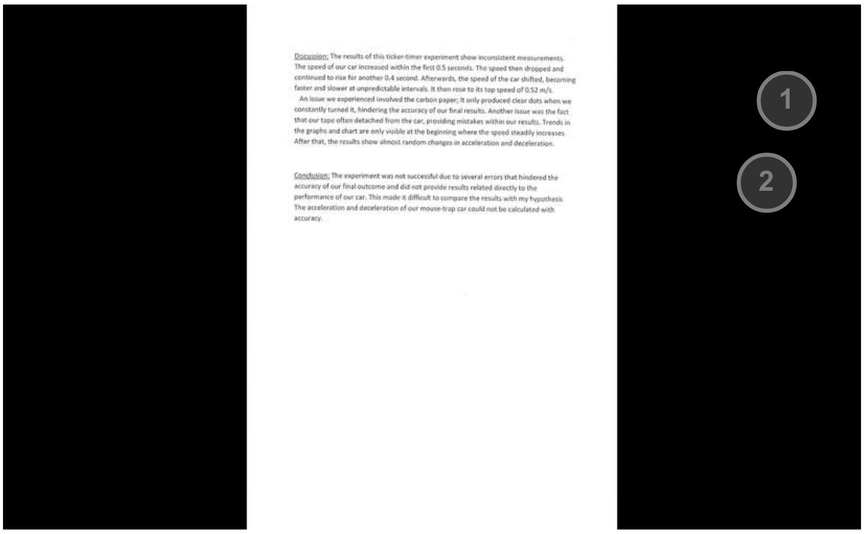
Annotations

1 **Mathematics**
Calculates average speed from the data collected



Annotations

1 **Science**
Displays the data in a segmented line graph



Discussion: The results of this ticker-timer experiment show inconsistent measurements. The speed of our car increased within the first 0.5 seconds. The speed then dropped and continued to rise for another 0.4 second. Afterwards, the speed of the car shifted, becoming faster and slower at unpredictable intervals. It then rose to its top speed of 0.52 m/s.

An issue we experienced involved the carbon paper; it only produced clear dots when we constantly turned it, hindering the accuracy of our final results. Another issue was the fact that our tape often detached from the car, providing mistakes within our results. Trends in the graphs and chart are only visible at the beginning where the speed steadily increases. After that, the results show almost random changes in acceleration and deceleration.

Conclusion: The experiment was not successful due to several errors that hindered the accuracy of our final outcome and did not provide results related directly to the performance of our car. This made it difficult to compare the results with my hypothesis. The acceleration and deceleration of our mouse-trap car could not be calculated with accuracy.

Annotations

1 **Science**
Evaluates the experimental method in detail and identifies several causes for errors in results

2 **Science**
Draws the conclusion that the flaws identified in the experimental method do not allow for validation of the hypothesis