To: The Education and Innovation Committee eic@parliament.qld.gov.au

SMC&PA Submission 127
Received: 7 May 2013

From: Andrew Ball

Dear Committee Members,

I have been teaching mathematics and physics for 17 years. I do not feel confident about the QSA and their approach to assessment.

My submission is set out under three headings.

Ensuring assessment processes are supported by teachers.

- Assessment is inconsistent from school to school
- QSA's guidelines change regularly and advice is contradictory
- When QSA's guidelines change, this information is not adequately communicated to the teaching community in a reasonable timeline. Primary mode of information dissemination appears to be via DRP advice, an unofficial physics sharing email list or by performing random checks of the QSA website.
- QSA bullies teachers who dare to voice different opinions

Student participation levels.

- Workloads on students have increased dramatically. Unfortunately, the QSA is now providing very different exemplars of A standard EEI assignments to those shown to teachers in Queensland over the last few years. What they are providing to you as the EIC as evidence for what an EEI task constitutes is very far removed from those on their website merely one year ago (which they have now taken down). Their current exemplar about sports equipment (8 pages long) is flawed (not complex in nature), and is not of a comparable standard to earlier exemplars (see 21 page long exemplar that is attached). The QSA will simply not acknowledge that students need to write EEI assignments of over 5000 words (and up to 10000 words) in order to satisfy A standards on the exit criteria. Keep in mind that many students wish to achieve A+ standard and must go beyond what is described by the QSA as a "typical" A standard.

  The QSA has backflipped in recent years about the word length of assignments and now states "only the discussion section needs to be 1500 words." But the discussion is merely one section of a much larger report! A word count of the QSA's previous A EEI exemplar reveals it to be well over 4000 words!!! This is not only representative of the constant contradictory advice which the QSA provide, but it shows what is really expected of students in Queensland.

  Consider this: many of our best and brightest have more than one of these tomes to produce if they study more than one science. The workload is unreasonable.
- Workloads on teachers have increased dramatically. If a teacher can peruse and adequately grade one of these EEI reports in half an hour, and has 25 students in a class, this would be 12.5 hours marking. Each report requires a drafting process, another 12.5 hours. Most Queensland teachers would have approximately 4-5 hours of marking and correction time provided during their working day by their employer. At this rate, it takes five weeks to draft and mark those EEI's for one class alone! A five week turnaround time is unacceptable for most schools, so teachers must work in their own time, after hours.

  Teachers are paid for a 30 hour working week (5 days by 6 hours). 25 hours of marking for one class is essentially four days of work, which is done in teachers own time after school and on weekends, and which is not paid. It is little wonder that we are not attracting the best and brightest members of society to a career that requires such a heavy workload after hours.

The ability of assessment to support valid and reliable judgments of student outcomes.

- Standards vary from school to school, district to district and year to year
- Grading with letters means that students with different marks get the same grade
- Large amounts of the course are assessed by assignments and these can be copied
- Time taken in assignments takes away from teaching time
- The assessment is inequitable. Students who can afford tutors, those with better writing skills and with family working in maths and science do better.
- New teachers at schools which are under resourced cannot cope
- Some assessment tasks do not allow good students to get the grade they deserve
- Long essays have no place in maths. Many students who excel at maths are not great at writing. This discriminates against them
- The use of long writing tasks discriminates against students from non English speaking backgrounds and boys
- The Evaluating and Concluding category shows that the criteria were designed with too much emphasis on the writing skills of the students. Get rid of the EC category.
- The criteria paragraphs which the QSA call standards, are highly subjective. The Trial-pilot and extended trial pilot process was lengthy and costly for the Queensland Government. Much of the time was spent in debate about the subjectivity of criteria statements, particularly for what constitutes an "A" standard. Teachers continue to experience the stress each year, of not being sure how their students' work will be judged at District Review Panel, with such standards that are so subjective.

I support state-wide exams set by teams of experienced teachers. The assessment could be: 50% external exam, 50% internal of which an EEI is one fifth (10% of the final total). Those who make decisions on curriculum in our schools should spend at least 6 months in the classroom every 4 years. Educational theorists without substantial classroom experience should not be employed in decision making positions.

Kind regards

Andrew Ball

[redacted]

APPENDIX :

Previous QSA exemplar. (21 page report is attached next page)

Sample student response: Standard A

Standard descriptors	Student response A
	Abstract The aim of this experiment was to determine the relationship between cross-sectional area of a conductive surface on the average acceleration at which the magnet descends and to investigate the effect of the changing temperature of the magnet on the average velocity that the magnet descends. The experiment was conducted by timing the descent of a magnet down aluminium wedges of different cross-sectional areas, and with the magnet at different temperatures, with the slope at a constant angle, and friction kept constant. It was found that the relationship between cross-sectional area and the average acceleration was $a = \frac{210.05}{A \times 10^{-6}} + 0.399$, which partially supported the hypothesis, and the relationship between the temperature of the magnet and the average acceleration was found to be a=0.009T+0.639, which supported the hypothesis. Introduction
Formulates a justified significant researchable question and hypothesis	Research Question: In the situation of a magnet descending down an inclined plane composed of a conductive surface that cannot be magnetized, how will the average acceleration of the descending magnet be affected by the cross-sectional area of the conductive surface it descends down and the temperature of the magnet as it descends? Aim: To investigate the relationship between cross-sectional area of the conductive surface on the average acceleration at which the magnet descends and the relationship between the temperature of the magnet on the average velocity that the magnet descends. Hypotheses: As the cross-sectional area of the conductive material increases; the average velocity at which the magnet descends will decrease in a linear relationship, with acceleration down the plane due to gravity and the force of friction as constants. As the temperature of the magnet increases; the average velocity at which the magnet descends will be directly proportional to the square of the temperature of the magnet, with acceleration due to gravity, and friction as constants. Justification of Hypothesis:
	Cross-sectional Area: The downhill force acting on the magnet is given by $F = mg\sin\theta$ Where F is the force, m is the mass of the magnet, g is acceleration due to gravity and sin0 is the angle of the slope. (Western Washington University, no date) And the friction acting on the magnet is given by $F = \mu mg\cos\theta$ (physicsclassroom.com, 2009) The movement of the magnet down the slope creates a magnetic field that varies in

<table>
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<td>Linking of algorithms, concepts, principles, theories and schema to find solutions in a complex and challenging situation</td>
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strength with time in relation to the aluminium. This results in an electromotive force, creating a potential difference in the material according to Faraday's law of induction:

$$EMF = Bv\ell \sin\theta$$

B is the strength of the magnetic field, v is the relative motion of the conductor and theta is the angle that the conductor cuts the magnetic field. (Nave R, no date)

According to Ohm's Law:

$$EMF = IR$$

EMF is the potential difference generated by the magnet's movement, I is the induced current and R is the resistance in the aluminium.

The resistance of a conductor is given be the equation:

$R = \frac{L\rho}{A}$ where R is the resistance, L is the length , p is the resistivity of the material and A is the cross-sectional area (Nave R, no date).

Therefore, the magnitude of the current in the aluminium is

$$I = \frac{Bv\ell \sin\theta A}{L\rho}$$

According to Lenz's Law, this magnetic field will act on the magnet to cause a force up the slope, as it much opposed the change that created it (ie. the downhill motion of the magnet). (Nave R, no date)

Magnetic fields can exert forces on current carrying conductors according to the law $F = BIL\sin\theta$, where B is the magnetic field of the magnet, I is the current and sin0 is the angle the current cuts the field. As the current-carrying wire does not move, the magnet experiences a reaction force of equal magnitude in the opposite direction. (Calvert J, __).

Therefore, the force that slows the motion of the magnet is given by the equation:

$$F = B\frac{Bv\ell \sin\theta A}{L\rho}\ell \sin\theta$$

Newton's second law of motion is that F=ma

Therefore, the acceleration of the magnet down the slope is given by:

$$a = \frac{mg\sin\theta - B\frac{Bv\ell \sin\theta A}{L\rho}\ell\sin\theta - \mu mg\cos\theta}{m}$$

If all but A is kept constant:

$$a = -kA + K$$

Therefore, $a \propto -A$

That is why it is hypothesised that the average acceleration of the magnet down the slope should be negatively directly proportional to the cross-sectional area, with acceleration due to gravity, and friction as constants.

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Presents ideas and data with discrimination to make meaning accessible to the intended audience

Temperature:

Magnets have a temperature dependency co-efficient (Tco-eff) depending on the material the magnet is made of. For example, the strength of a NdFeB magnet drops by about 12% per degree centigrade rise (magnetman.com, no date) (Ninggang Magnets, no date), up to its maximum operating temperature.

Given this, $B = {}^{-}T_{co-eff} \times T \times B$, where B is the maximum field strength the magnet can produce.

$$a = \frac{mg\sin\theta - {}^{-}T_{co-eff}TB\dfrac{{}^{-}T_{co-eff}TBv\ell\sin\theta A}{L\rho}\ell\sin\theta - \mu mg\cos\theta}{m}$$

If all but T is kept constant:

$$a = K + T^2$$

Therefore, $a \propto T^2$

The composition of the magnet used in this experiment was not known, however, all magnets experience a decrease in magnetic field strength with temperature rises.

That is why it is hypothesised that the average acceleration of the magnet down the slope should be directly proportional to the square of the temperature of the magnet, with acceleration due to gravity, and friction as constants.

Theory Review:

The expected slowing of the magnet as it descends aluminium wedges of different thicknesses and the expected decrease of slowing with the magnet at different temperatures is predicted by the physics concepts of magnetism, magnetic induction and Lenz's law.

Magnetism is an effect created by moving charged particles. In an atom, each atom orbiting around the nucleus creates a magnetic field.

Material removed due to copyright restrictions.

Diagram of the magnetic field created by the movement of electrons around an atom.

In many atoms, depending on the positioning of electrons in shells, the net effect of all the electrons means that there is no overall magnetic field on the atom.

Additionally, even in materials made up of atoms with net magnetic fields, on overall magnetic field for the whole material does not exist as an overall magnetic effect is cancelled out as the fields do not align (Brown K, 2009)

Material removed due to copyright restrictions.

The diagram showed an alignment of magnetic domains.

Most substances, like aluminium in this experiment, are classed as diamagnetic. The external magnetic field causes the electrons to orbit around the atom in a specific way, and according to Lenz law, this must be in such a way as to oppose the applied magnetic field, so the substance is slightly repelled by the magnet. (Brown K, 2009)

Comparison and explanation of complex concepts, processes and phenomena

Some substances are paramagnetic. The electrons within each atom of the substance have net magnetic fields, so when exposed to an external magnetic field, the individual atoms fields tend to line up with the applied field, causing an overall attraction. However there is still a diamagnetic effect.(Brown K, 2009)

Other substances, like the magnet in this experiment, are ferromagnetic. This means that in most situations, they have an overall net magnetic dipole field. The magnetic domains of individual atoms line up, and additionally, there is an alignment of the intrinsic spin axes of the individual electrons in each atom, and across the whole material. (Brown K, 2009)

The strength of the magnetic field created by a ferromagnetic substance decreases with temperature. The spin axes of the electrons are believed to align when there is a specific distance between each electron in the shells of each atom. As the temperature rises, electrons move within the atoms, meaning the spins will no longer align, and additionally, the random motion of atoms effects the alignment of magnetic domains and intrinsic spin axes across the entire material (Brown K, 2009). Each ferromagnetic substance has a curie temperature, above which magnetic domains no longer align, and the substance loses its overall magnetic field and will now only act as a paramagnetic substance. (UCLA physics, no date).

When there is a relative motion between a charged particle and a magnetic field, the particle will experience a force perpendicular to both the direction of the field and the motion of the particle, known as the lorentz force (Nave R, no date). Due to this effect, when there is relative motion between an electrically conductive material and a magnetic field, the free electrons will all experience a force in a particular direction, creating a potential difference, and current will then flow when the motion changes. This is known as Faraday's law, and the size of the potential difference created is proportional to the strength of the field, the speed of the relative motion between the field and particle, and the angle that the motion of the particle cuts the field. This then causes current to flow in the conductor, and they flow in circular

	patterns, as particles under the influence of a lorentz force more in circles. (NDT Resource Centre, no date)
	Electric currents also create a magnetic field, which wraps around the current.
Principles have been linked and applied appropriately in the complex and challenging situations linked to the research focus.	Material removed due to copyright restrictions. The diagram showed the magnetic field of a current carrying wire.
	According to Ampere's law, stronger currents have stronger magnetic fields, and the field strength decreases with distance depending on the magnetic permeability of the substance that surrounds the wire, and as wires have magnetic fields, they experience a force in the presence of a magnetic field. (Nave R, no date)
	Lenz's Law states that an induced current will flow in such a way that it creates a magnetic field to oppose the magnetic field that created it, which is why the magnetic fields of the eddy currents will oppose the downhill motion of the magnet, which created them. It is related to the conservation of energy in that if the fields accelerated the magnet's movement, the movement would induce larger currents, which would further accelerate the magnet. Therefore, from a low energy input to push the magnet, it would result in a very large energy output from the kinetic energy of the magnet and the joule heating of the conductor, and the magnet would be able to keep accelerating forever from only one push. (Launceston College, no date).
Reproduction and interpretation of complex and challenging theories	Material removed due to copyright restrictions. The diagram showed the magnet is repelled from the end of the magnets, to oppose the increase in magnetic flux as it moves between the magnets, and it is attracted back into the magnets at the other end to oppose the decrease in magnetic flux.
	Due to Lenz law, the magnet will experience a net force up the slope to opposing the force of gravity pulling it down, and so the magnet should descend the slope more slowly, as the net force downhill has decreased.
	The source of the braking force on the magnet is a Lorentz force on every charged

particle in the magnet up the slope leading to a net uphill force, acting against the downhill motion of the magnet.

Orientation to the overall design:

The overall design of both experiments involved a v-shaped 1 metre long wedge of aluminium (figure 1), being placed against an object to make a constant angle with the floor, thereby ensuring a slope of the same gradient, which was measured with a protractor. A magnet was placed on the aluminium, and after counting to three, it was released, and its descent down the 1m wedge was timed using a stopwatch, and this information was used to find the average acceleration.

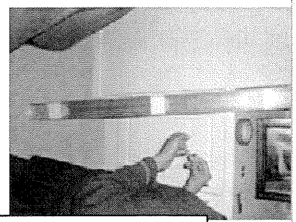


Figure 1: the V shaped aluminium wedge set up for the experiment

Refines investigations, manages research tasks effectively

In the first experiment, the manipulated variable was the thickness of the aluminium wedge, and in the second, it was the temperature of the magnet. The chosen values for the manipulated variable of cross-sectional area were 110.04, 341.04, 401.04, 572.04, 632.04 and 863.04mm2. Different areas were made by stacking different combinations of 5 wedges, and these values were the widest variation that could be developed from the limited sizes. The chosen values for the manipulated variables for temperature were room, as this could be easily controlled, and the highest and lowest temperatures found to be obtainable through the water bath system were 2o and 80 o. It was decided to do one below, and above room temperature, which were the 10 o and 56 o trials. For the last trial it was decided to do 30 o.

Aluminium was chosen as the metal for the slope as it is not paramagnetic, a good conductor of electricity and readily available in the required form. A diamagnetic material was required as otherwise, in the presence of the magnet's field, the magnetic domains within the material would have aligned, and it would have become a magnet itself, and the eddy current phenomenon required for this experiment would not have occurred. Low resistance would have increased the magnitude of the eddy currents formed, creating a measurable braking effect.

Assesses and applies risk management procedures related to the investigation and safely selects and adapts equipment.

For the experiment on cross-sectional area, there were a number of controlled variables. The temperature of the magnet and aluminium needed to be constant, as according to the theory discussed earlier, temperature increases decrease the strength of the magnet, and temperature increases will increase the resistivity of the aluminium. This was controlled by conducting all the experiments at room temperature over a period of about 30 minutes, decreasing the possibility for variations in room temperature.

The same aluminium wedge was used as the top of the wedge piles for all different thicknesses and the same side of the magnet was used for each descent, and this would have ensured that the same two surfaces were coming into contact each time, keeping the co-efficient of friction constant, and therefore the force of friction acting on the magnet. Therefore, any slowing could be attributed to a magnetic effect, and not friction changes, as this would also oppose the downhill motion. The size of the eddy current produced is proportional to the speed the magnet moves down the aluminium. Therefore it was important to ensure the acceleration down the slope would be constant. This acceleration is given by a=gsinø, so the angle of the slope needed to be kept constant, using a protractor.

	For the temperature experiment, it was important to ensure the magnet remained at the desired temperature over all trials, so this is why the magnet was put back in the water bath after each trial. Planning and Preliminary Trials Introduction: It was decided to use values for the manipulated variable of cross-sectional area of 110.04mm and 863.04mm. These were the proposed thinnest and thickest values, in order to see if a measurable difference could be obtained between the two. It was decided to use the values for the manipulated variable of temperature of 0 degrees and 100 degrees. These were the proposed hottest and coldest values, in order to see if a difference was apparent between the two.
Gather and record and process valid data	These trials were also used to choose other aspects of experimental design, such as the angle of the slope, the side of the aluminium wedge used, and wether aluminium foil would work. However the methods used to determine these factors were simply based on observations, through trial and error, so no stepwise method is recorded here. Method and Materials Aluminium wedge of dimensions 40mm x 40mm x 1.4mm x 1m (Thin) 2 Aluminium wedges of dimensions 40mm x 40mm x 3mm x 1m (Medium) Aluminium wedge of dimensions 50mm x 50mm x 3mm x 1m (Fat) Bar Magnet of dimensions 9mm x 16mm x 76mm Semi-circle protractor Stopwatch Blu-tack 1. All of the five aluminium wedges were placed on top of each other, with the thinnest wedge as the top surface 2. The wedge was placed against the bench so that it made a V, and an angle of 70 degrees with the floor, which was determined using a protractor
Devises and designs efficient/effective investigations	3. A magnet, that had been marked with a piece of masking tape, was placed on the wedge, and after counting to three, the magnet was released by a person, who simultaneously timed its descent using a stopwatch. 4. Timer watched the end of the wedge at eye-level 5. Results were recorded 6. Steps 2-5 were repeated 9 times for the single thinnest wedge Temperature: 1. All of the five aluminium wedges were placed on top of each other, and they were secured together with masking tape after it was observed that they did not touch properly without it. The thinnest wedge was the top surface 2. The wedge was placed against the bench so that it made a V, and an angle of 70 degrees with the floor, and was secured in place with blu-tack 3. Ice was poured into a plastic bowl with a thermometer and the magnet in it, and one minute was timed with a stopwatch 4. After one minute, the magnet was removed, was placed on the wedge, and after counting to three, the magnet was released by a person, who simultaneously timed its descent using a stopwatch. 5. Timer watched the end of the wedge at eye-level 6. Results were recorded 7. Water boiled from a kettle was placed in a plastic bowl with a thermometer and the magnet in it, and two minutes was timed with a stopwatch 8. Steps 4-6 were repeated 9 times, then step 7 was repeated

Sample student response: Standard A

Selects, adapts and applies technology to gather and record and process valid data

Results

Cross-sectional Area:

Cross Sectional Area (m)	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average
110.04	1.87	1.19	1.38	1.29	1.57	1.46
863.04	0.7	0.6	0.53	0.8	0.84	0.694

Temperat ure	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average
2	1.31	1.33	1.21	1.20	1.18	1.25
80	0.85	0.79	0.82	0.91	0.90	0.85

Refines the investigation and adapts the equipment

Discussion:

Although not included in the method, a few trials were conducted using aluminium foil wrapped around a plank, but this was abandoned as no effect could be observed, and there were lots of bumps in the aluminium, and the magnet got sometimes stuck behind bumps and didn't move at all.

It was decided to use v-shaped planks of aluminium, and by trying out a range of different angles and observing the descent of the magnet, it was decided that 70 degrees appeared to cause the slowest descent. However no actual times were recorded. It was decided that the planks could not be placed flat, but had to be placed so that they made a V, as otherwise the magnet would often flip off the side. Blu-tack was very useful in holding the plank in position. It was decided to base the rest of the experiments on using the planks so that they made a V, and an angle of 70 degrees with the floor.

In order to see if an observable difference would appear in the area results, it was decided to test the thinnest and thickest thicknesses and see if there was a significant difference between the time taken to descend. There were 5 different planks of different widths, and they all had to be stacked together to make the largest thickness. It was found that it was difficult to keep the planks together, and it was decided that masking tape was quite effective for this, although care had to be taken that it didn't impede the descent of the magnet. This allowed the wedge to remain stable and helped ensure all parts of the metal were touching so that the whole thickness would be available to conduct electricity, as whilst currents might still form independently in each layer, the hypothesis for this experiment required one conductive thickness in order to decrease resistance to current flow, and increase current size and therefore the braking effect.

All of these changes were implemented before the results for preliminary trials were recorded. It was also decided to put a piece of tape of the magnet for the side that would touch the plank because it was difficult to remember which side of the magnet was used.

Refines the investigation and adapts the equipment →	It was decided that for temperature, there would be an aim of a temperature to reach, before the magnet was put in the water, but the temperature of the water bath would be taken after the two minutes, and this would be considered the temperature of the magnet, as the temperature continued to drop over the two minutes by a margin that was felt too large to ignore. The values of 100o or 0 o were found to be unachievable with the time and material constraints. 100 o was not reached by the kettle used, and the ice never cooled the water below 0 o. The magnet could have been left in the freezer for a long period of time, but this was not possible due to time constraints. It was observed, by holding the magnet that it became hotter, or colder very quickly, so it was decided that it needed to be replaced in a hot or cold-water bath after each trial, or the experiment would not be well controlled. It was found that one person could easily both time and release the magnet, whilst also watching for where it stopped at eye level, and this may have possibly reduced the impact of reaction times, as the timekeeper knew exactly when the magnet was released. Times were found to be very small, and the differences between the largest and smallest values for the manipulated variables, whilst observable, were also quite small, so it was decided that 9 trails were needed to help decrease the effect of error due to reaction times and human error. Conclusion A number of important changes were made to the experiment design based on preliminary trials. Firstly, the idea of aluminium foil and planks was abandoned for the store-bought aluminium wedges. It was also decided that the planks would be placed as a "V" against the wall, and would be secured with blu-tack, and placed at a slope of 70 degrees, and that the same person would time and release the magnet, and 9 trials would be conducted. For the area experiment, it was decided to tape the wedges together with masking tape so that they were totally in contact, and for the temperature experiment, it was decided that the magnet needed to be heated up after each of the nine trials, and that simply the highest achievable and lowest achievable temperatures would be used as opposed to 0 and 100 degrees, which were found to be too difficult to achieve. Final Method Materials: As previous experiment Thickness 1. 1 thin Aluminium wedge of dimensions 40mm x 40mmx1.4mm x 1m was placed against a ledge. A protractor was used to ensure that the angle between the floor and the wedge was 70 degrees 2. Blu-tack was placed either side of the wedge to secure it. 3. A magnet, that had been marked with a piece of masking tape, was placed on the wedge, and after counting to three, the magnet was released by a person, who simultaneously timed its descent using a stopwatch, and watched the end of the wedge at eye level. 4. Results were recorded 5. Steps 1-5 were repeated 9 times

Selects, adapts and applies technology to gather and record valid data

6. The next thickness wedge was constructed by stacking the thin and medium wedges together, whilst ensuring the thinnest always remained the top layer
7. Masking tape was wrapped around the top, middle and bottom of the aluminium wedges
8. Steps 1-6 were repeated
9. Steps 7-8 were repeated using the thin and fat wedges, the thin, and two medium wedges, the thin, medium and fat wedges and the thin, two medium and fat wedges.
10. Using the recorded data, an average velocity was calculated using the equation v=d/t, and an average acceleration was calculated using the equation v=u+at, given u=0m/s.

Temperature

Materials

As previous experiment
500mL of water

1. The wedge was constructed by stacking all of the wedges together, with the thinnest as the top layer
2. Masking tape was wrapped around the top, middle and bottom of the aluminium wedges
3. 500mL of water was heated until the kettle switched off, and poured into a glass bowl, with a thermometer, and left to cool until the desired temperature was reached (86 degrees)
4. The magnet was immersed in the water for two minutes, which was timed with the stopwatch
5. A magnet, that had been marked with a piece of masking tape, was placed on the wedge, and after counting to three, the magnet was released by a person, who simultaneously timed its descent using a stopwatch. The timer watched the end of the wedge at eye level.
6. Step 3-5 were repeated 9 times, and all results were recorded
7. Steps 3- 6 were repeated for the 500 C and 300 C
8. Step 5 was repeated for room temperature
9. A bowlful (approx. 500g), of ice was placed in a glass bowl, with a small amount of water (approx. 20mL), and a thermometer
10. When the temperature stabilised at the lowest temperature, the magnet was added to the bowl for 2 minutes, which was timed with a stopwatch
11. Steps 5-6 were repeated once
12. Steps 10 and 11 were repeated, but the magnet was not added until the temperature stabilised at 10 degrees.
13. Steps 5-6 were repeated once
14. Using the recorded data, an average velocity was calculated using the equation v=d/t, and an average acceleration was calculated using the equation v=u+at, given u=0m/s.

Tables display relationships between patterns in the data.

Results (only averages have been included for brevity)

Table 1: Results from the experiment to find the relationship between the cross-sectional area and the acceleration of the magnet

Cross-sectional Area	Time	Difference from average	Average Acceleration
110.04mm2			
Average	0.661	0.11	2.325
341.04mm2			
Average	0.967	0.024	1.073
401.04mm2			
Average	1.002222222	0.009	0.996
572.04 mm2			
Average	1.113	0.017	0.808
632.04 mm2			
Average	1.186	0.1433	0.712
863.04 mm2			
Average	1.349	0.013	0.550

Graphs display relationships between patterns and trends in the data.

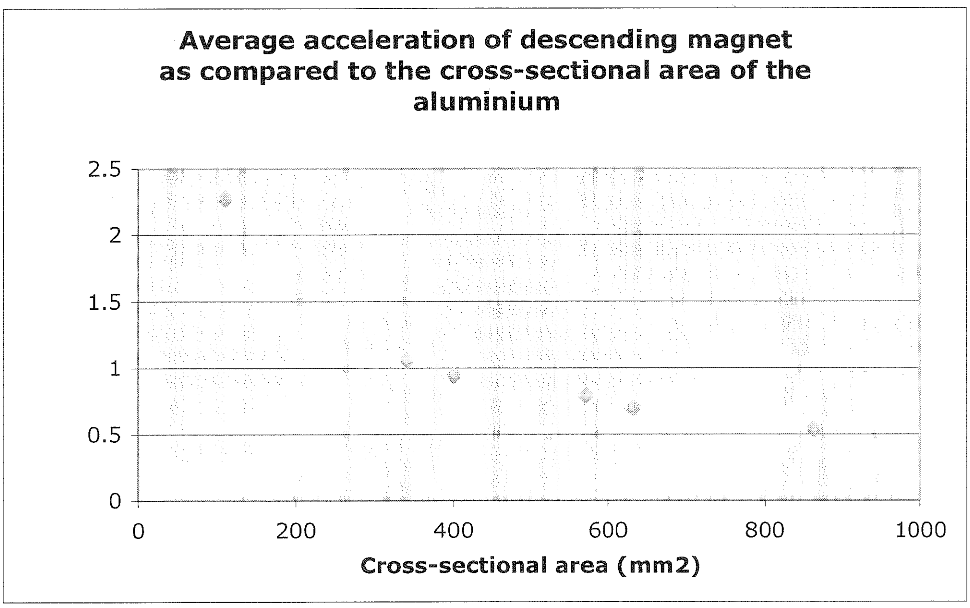


Figure 6: Graph of the average acceleration of the descending magnet as compared to the cross-sectional area of the aluminium.

Table 2: Results from the experiment to find the relationship between the temperature of the magnet and the average acceleration

Temperature in degrees C	Time	Difference from average	Average Acceleration
2			
Average	1.224	0.027	0.668
10			
Average	1.217	0.019	0.676
21			
Average	1.142	0.076	0.775
30			
Average	1.12	0.033	0.800
56			
Average	0.864	0.028	1.344
80			
Average	0.898	0.033	1.249

Graphs display relationships between patterns and trends in the data.

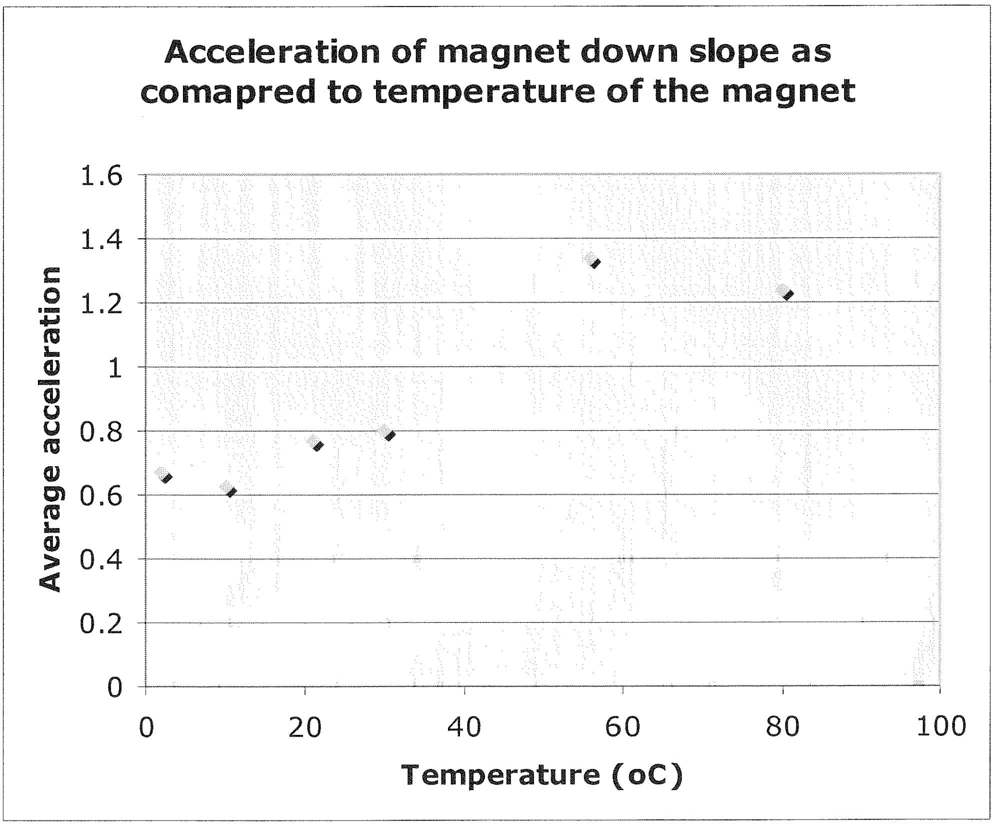


Figure 7: Av acceleration of the descending magnet as compared to the temperature

Sample student response: Standard A

Linking and application of algorithms

Percentage Variation from mean:

$$\% variation = \frac{trial}{mean} \times 100$$

Sample Calculations:

Average Acceleration

v=d/t (70deg. downhill)

v=u+at and as u=0m/s

Therefore, v=at

Therefore

$$\frac{d \div t}{t} = a$$

Eg. For 2 degrees, trial 1:

$$\frac{1 \div 1.2}{1.2} = a$$

$$a = 0.6845 m/s/s$$

Average Acceleration for each trial:

$$Av.a = \frac{sum \text{ of results}}{9}$$

Eg. Trial 110.04mm

$$\text{Av.a} = \frac{0.65 + 0.6 + 0.63 + 0.77 + 0.6 + 0.7 + 0.65 + 0.68 + 0.67}{9}$$

$$= 0.661$$

Determining the Relationships:

From Figure 6, the relationship between cross-sectional area and average acceleration appears to be an inverse relationship.

To confirm relationship:

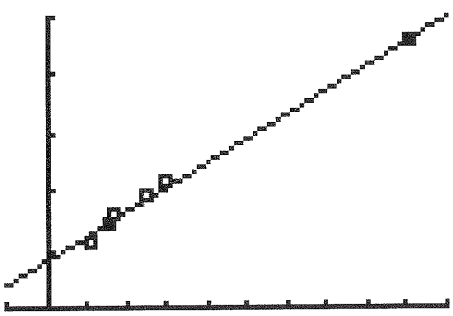


Figure 8: Graph of a vs. 1/A

As this graph shows a linear relationship, the data does fit an inverse proportion relationship.

Using regression facility, the equation of this line is a=210.05 Ax 10 +0.399

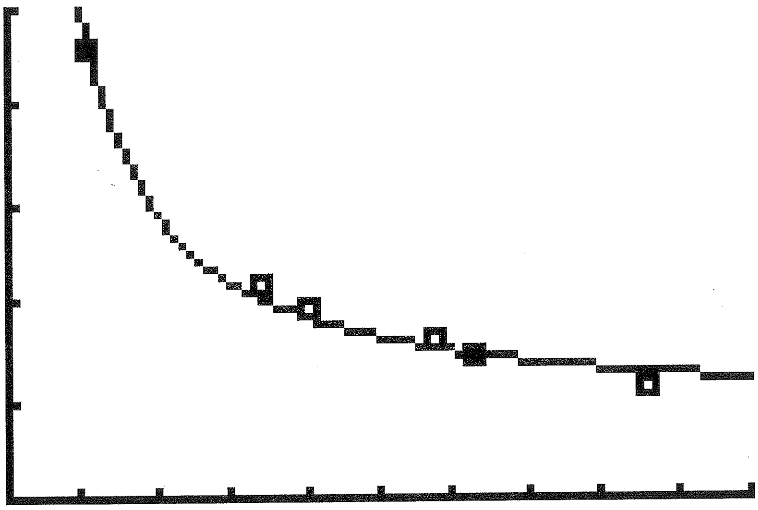


Figure 9: Graph of original data with the developed relationship

Graphs display relationships between patterns and trends in the data.

Developing relationship for temperature experiment:

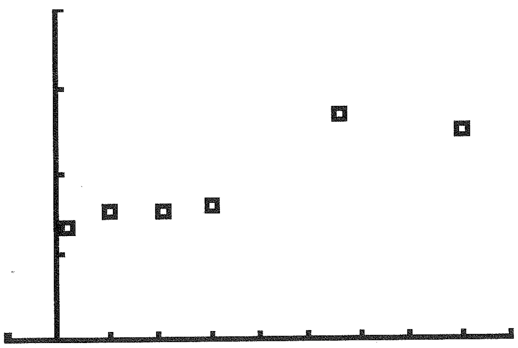


Figure 10: Graph of Temperature as compared to average acceleration

Systematic analysis of data to identify relationships between errors and anomalies

There is not a very strong trend, and the results could be linear or quadratic

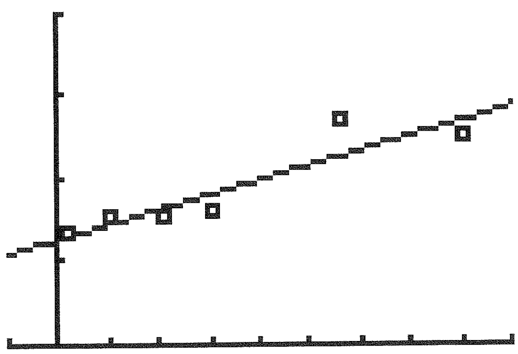


Figure 11: Graph of results with the developed relationship

Using a regression facility, the relationship was found to be a=0.009T+0.639

This had a r value of 0.8346

Developing a square relationship:

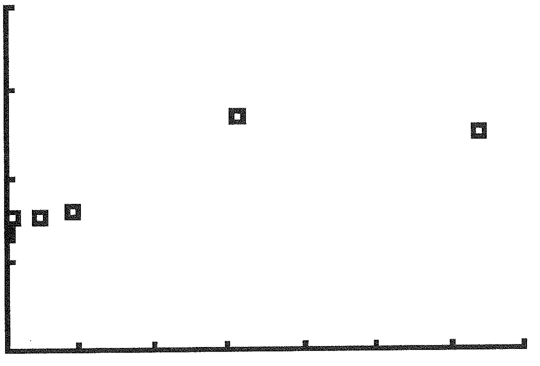


Figure 12: Graph of a vs. T

As this graph is a straight line, the data also fits a square relationship, and using the regression facility, the equation of the line is a=9.8x10 T +0.7533.

The r value is only 0.7397, therefore, the original linear relationship was a better fit for the data

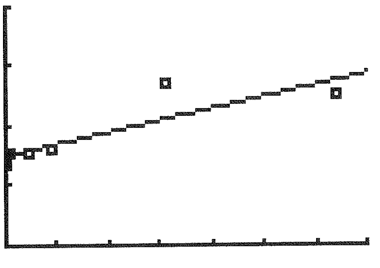
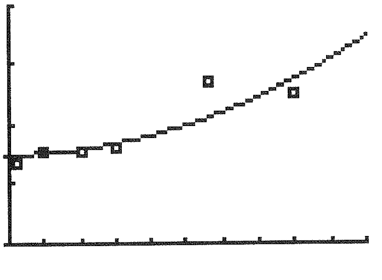


Figure 13: Graph of a vs. T with line

Figure 14: Graph of a vs. T with square relationship



The better fit for the data appeared to be the linear relationship of a=0.009T+0.639

Analysis Discussion and Interpretation of Data

Systematic analysis of primary data to identify relationships between patterns, trends, errors and anomalies

The results from the experiment to determine the relationship between the cross-sectional area of the aluminium wedge and the average acceleration of the magnet downhill found an inverse proportion relationship of $a = \frac{210.05}{A \times 10^{-6}} + 0.399$. This partially supported the hypothesis as area increased as acceleration decreased, however it did not show the predicted negative direct proportion relationship. The 1104.04mm trial was mainly responsible for the inverse relationship, as it was much higher than the rest of the data, however its average was in fact lowered by a large anomaly in trial 4, which was a time 16.46% greater than the mean, lowering the overall average. Trials 2 and 5 seemed very fast in comparison to the rest of the data, 9.09% below the average. These could have been due to timing errors, or other problems in experimental design as discussed later, but the combined effects of all these anomalies probably didn't affect the trend development or average greatly. All other trails were relatively consistent.

Decreases in acceleration due to increases in cross-sectional area were expected by theory, as there is less resistance in conductors of larger cross-sectional areas. The movement of the magnet down the slope induced potential differences, and when the resistance was lower, currents of greater magnitude flowed. Larger currents produced stronger magnetic fields according to Ampere's law, and according to Lenz' law, the magnetic fields of the magnet and the current must interact so that the phenomenon that induced the current in the aluminium is opposed. This manifests as a braking force uphill, as the current is induced by the downhill movement of the magnet. By increasing the cross-sectional area, the magnetic field of the current is increased, and therefore, the uphill braking force experienced by the magnet would be larger, resulting in a smaller net force downhill, and therefore decreasing the average downhill acceleration.

Discussion related to errors and anomalies

Measured quantities would have contributed to error in the results. It is very likely that error existed in the recorded times, due to human error and reaction times, as it is likely that the stopwatch was not pressed exactly as the magnet was released, nor exactly when it reached the ground. The angle of the slope may not have been constant throughout all experiments, due to human error in measuring it with a protractor. This would have changed the initial acceleration of the magnet down the slope over the trials, changing the size of the initial braking force, as eddy current formation is dependant on the speed of the relative motion between the magnet and the aluminium. The cross-sectional areas of the wedges were calculated using information from the manufacturer, and therefore, the accuracy of these numbers would have affected the results.

There were also a number of problems in the experimental design that may have contributed to errors. It was observed that when multiple wedges were used at once to make the larger thicknesses, the metal wedges did not stay in contact perfectly along the whole length of the wedge. The theory used to predict the negative direct proportion relationship required a constant cross-sectional area in order to uniformly reduce resistance in the wedge. This was not achieved in this experiment, which would have influenced the data as resistance would have been altered by a factor other than area. The effects of this may have been seen in the results, as the 110.04mm trial was the only one that could not have been affected by this, and it was greatly different from the trend of the rest of the data, creating an inverse

	relationship. In the future, it would be better to use different wedges made of different thicknesses, as opposed to constructing them, to eliminate this problem.
Refinement of the investigation →	Resistance in the aluminium would also be dependant on the temperature of the aluminium. As temperature increases, the random motion of atoms within the metal increases, and therefore there are more collisions between the atoms and the moving electrons, which increases the resistance, by decreasing the ability of current to flow. Due to the eddy currents, the metal would be subject to joule heating, which would increase the temperature of the aluminium. The currents were of a small magnitude, for a short time, so the small amount of heat produced may have been lost quickly to the surrounds, therefore not affecting the results. Additionally, no trend was apparent that trails became successively faster due to increased resistance. However, if this effect were able to alter the temperature of the aluminium, temperature would not have been constant over all trials, as different sized currents would have been induced in the different areas, affecting the resistance in the aluminium, and therefore the magnitude of the braking force. In the future, it would be better to leave a larger period of time (a minute for example), between each trial to ensure this did not occur, instead of performing them in quick succession.
	The results from the experiment to determine the relationship between the magnet's temperature and average acceleration found that a=0.009T+0.639. This supported the partially supported the hypothesis, because as temperature increased, acceleration increased, but it was found to be directly proportional instead of proportional to the square of the temperature. However, there was not a strong linear correlation in the data. The 56 o trial seemed overly high, but there was a high level of precision in these results. It is more likely that the 80 o trial was too low, as it was affected by an anomaly in trial 3 which differed from the average time by 11.36%, possibly due to poor timing or temperature control. The 21o trial had a very low precision, and the average was lowered by anomalies in trials 1 and 3, which were lower than the average by 5.07% and 13.85% respectively. This was probably due to timing errors.
Explores scenarios linked to the research focus suggesting possible outcomes, and generates justified conclusions and recommendations →	Increases in acceleration caused by increases in temperature were expected by theory, as there is the magnetic field strength of a magnet decreases with temperature. The increased kinetic energy of the material caused an increase in the random motion of the electrons and atoms, negatively impacting on the alignment of magnetic domains, and electron spin axes across the material, decreasing the strength of the magnetic field. The hotter, weaker magnets therefore induced weaker currents, according to Faraday's law, and these weaker currents produced weaker magnetic fields, according to ampere's law, and therefore, the braking force on the magnet was smaller, as each charged particle in the magnet would experience a smaller lorentz force, and therefore, the downhill acceleration would be faster as compared to a stronger magnet.
Discussion of errors and anomalies →	Error in this experiment would have existed in the same measured values as in the area experiment; however, it would have also existed in the temperatures recorded. It is likely there was human error in reading temperatures and the results were limited to 1 decimal place by the thermometer used. Also, the magnet would not have been at the exact temperature recorded before it was removed from the water bath, and would not have remained constant, as heat was continually lost to, or absorbed from the surroundings. The magnet would have moved closer to room temperature the longer it was taken out of the water bath for, and therefore the

magnetic field of the magnet would have also changed.

It is also possible that 2 minutes in the water bath was not long enough to alter the entire magnet's temperature, and atoms in the centre of the magnet would not have had the alignment of magnetic domain and intrinsic spin axes altered by the temperature change, so the magnetic field would not have been altered to the extent predicted. In the future, it would be better to expose the magnet to the desired temperature for longer.

Explores scenarios linked to the research focus suggesting possible outcomes, and generates justified conclusions and recommendations

Additionally, the increased temperature of the magnet may have changed the co-efficient of friction between trials, affecting the results.

For both experiments, there was a poor choice in values for the manipulated variable. For area, there was not an even spacing between data points. Some of the points were very close together (eg. 341.04 and 401.04, and 572.04 and 632.04), so the results for acceleration were very similar, making it difficult to develop a relationship. The comparatively large difference between the points of 110.04 and 341.04 may have contributed to the development of a inverse relationship, as opposed to linear. Although it seemed much higher than the general trend of the data, the lack of data in between these two values meant it was not possible to decide wether this trial was an anomaly or not, and there was no information about how the relationship may have developed between these two points. In the future, it would be better to use a much greater range of thicknesses, with an even distance between each data point. In this experiment, the cost and availability of materials made that difficult.

There were similar problems in the temperature experiment. Temperatures could only be tested over a small domain (from 2 to 80 degrees), due to the limitations of using a water bath to change temperatures. In the future it would be much better to try to use a greater range of temperatures. Once again, there were uneven distances between data points, with many more trials of lower values than higher values, and this may have affected trend development, as whilst a linear trend was very clear in low values, it was difficult to determine the trend over higher values, and therefore difficult to develop an appropriate relationship. It would have been preferable to have even distances between data points.

Additionally, both experiments could have been conducted on a longer ramp, so that the times would be longer, helping reduce the effect of timing errors on results, and copper would be better to use than aluminium, as copper has a lower resistivity, and larger current could flow, so the effect would be larger, and a stronger magnet, which would also make a larger current flow. Both these changes would make effects more measurable.

For both experiments, it was stated that the relative motion between the aluminium and the magnet needed to be constant. Even though the magnet started at a constant acceleration, a braking force would have been experienced, the magnet would slow, and then a braking force of a different magnitude would be experienced, so the velocity and acceleration would be constantly changing, until the braking force and downward force were balanced and the object reached terminal velocity (Batten G, no date). In these experiments, the velocity would have definitely fluctuated for some of the descent, even if a terminal velocity were reached. In the future, it may be better to allow the magnet to slide for a bit until it has reached terminal velocity before timing begins, and calculate the average velocity instead of acceleration.

It would also be better to wipe the surface down after each trial, to help keep the surface clean and therefore friction constant. Sometimes the magnet appeared to become stuck on something, which was possibly sticky glue from the masking tape.

Possible future experiments could include investigating the other factors that affect magnetic braking, such as the changing the material the conductor was made of, changing the temperature of the conducting material, or making slits along the conducting material to stop currents from forming, or using magnets of different strengths.

Conclusion

The relationship between the cross-sectional area and the average acceleration of the magnet was found to be $a = \frac{210.05}{A \times 10^{-6}} + 0.399$, when the temperature for both the magnet and aluminium, friction and initial acceleration were constant. This result partially supported the hypothesis, as a negative direct proportion relationship was predicted. The relationship between the temperature of the magnet and the average acceleration of the magnet was found to be a=0.009T+0.639, when the friction, temperature of aluminium and initial acceleration were kept constant, which supported the hypothesis.

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Some research details

The **Scottish Qualifications Authority's investigation of the QSA assessment processes** states on page 12 that "It might be thought that this degree of externality would be sufficient to allow young Queenslanders to demonstrate their fitness to enter, for example, HE. Anecdotal evidence, however, tends to indicate that there might be a perception in Australia in general that those emerging from the Queensland internal assessment system will always be seen as less well qualified than those who have been through an external assessment system in other states."

On page 22

"It would be essential in Scotland to ensure that any such external exit assessment was immediately credible with its end-users, without the need for any further assessment such as the university entrance examination required in Finland. Candidates having undergone an internally-assessed system must not be disadvantaged by a perception that it is less rigorous than other systems that are externally assessed."

Not exactly a glowing recommendation! Scotland decided not to follow the QSA model.

http://www.sqa.org.uk/files_ccc/PNP_ResearchReport1_TheAssessmentSystemsFinlandQueensland.pdf

Another more recent assessment is by **Prof Gordon Stanley of Oxford.**

http://oucea.education.ox.ac.uk/wordpress/wp-content/uploads/2011/01/2009_03-Review_of_teacher_assessment-QCA.pdf

Read **'Experimentation on the Science Syllabus puts feelings before facts'** (quote below). Recall that the QSA refers to its system of assessment as "World's best practice."

"The view of science as outlined by the Queensland Studies Authority was utterly rejected by the Australian Council of Deans of Science, representing the heads of science faculties in the nation's universities. The council's executive director, John Rice from Sydney University, said it was a misleading view of science and misunderstood "the unique way in which science goes about understanding things".

http://mediaspinners.blogspot.com.au/2012/07/oz-science-ruined.html

For teachers of Mathematics

A forum for comments on Qld high school maths http://www.platoqld.com/?page_id=23

US Mathematician Bill Quirk contrasts mathematics with 'education mathematics' (various articles) http://www.wgquirk.com/BQMath.html

Biology, Chemistry and Physics: A compilation of some Queensland teachers' comments

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