National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Exemplar for Internal Achievement Standard

Physics, Earth and Space Science Level 1

This exemplar supports assessment against:

Achievement Standard 92045

Demonstrate understanding of a physical phenomenon through investigation

An annotated exemplar is a sample of student evidence, with a commentary, to explain key aspects of the standard. It assists teachers to make assessment judgements at the grade.

New Zealand Qualifications Authority

To support internal assessment

Grade: Achieved
For Achieved, the student needs to demonstrate understanding of a physical phenomenon through investigation. This involves describing the relevant physics concepts and relationships involved in a physical phenomenon, using evidence. The student demonstrates understanding of falling objects by: • recording the data they collected with their group in a results table and graph • quoting a data point in the graph description • describing that when an object is starting to fall, its velocity and drag are small, but will increase (and referring to the relationship between them). For Merit, the student could show how they calculated speed, or include a clearer explanation of how drag increases until it equals gravity force (weight) in size, which results in terminal velocity for the falling object.

Achieved
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On 14 October 2012, Felix Baumgartner broke multiple world records when he jumped from a helium balloon in Earth's stratosphere, skydiving 39 km and reaching a top speed of 1357 km/h before landing safely back on Earth with a parachute.

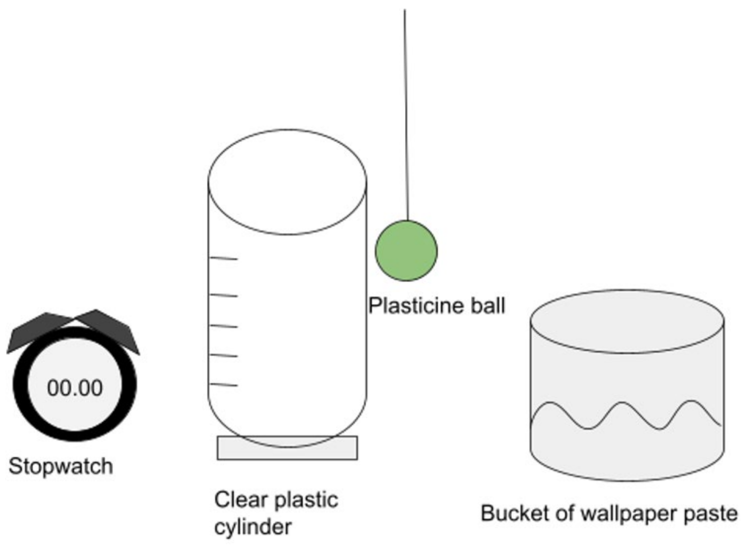
You will be provided with a large measuring cylinder, stop watch, ruler, plasticine and balance.

The AIM of the experiment is:
The aim of the experiment is to find the relationship of the time it takes for the plasticine ball to fall in the different amounts of wallpaper paste in the measuring cylinder.

Which is the INDEPENDENT VARIABLE?
The amount of wallpaper paste in the cylinder.
We will be putting different measurements of wallpaper paste in the cylinder to drop the plastercine ball in.

What range of values will be used?
0 to 0.50cm

Which is the DEPENDENT VARIABLE?
The speed that the plastercine ball travels.

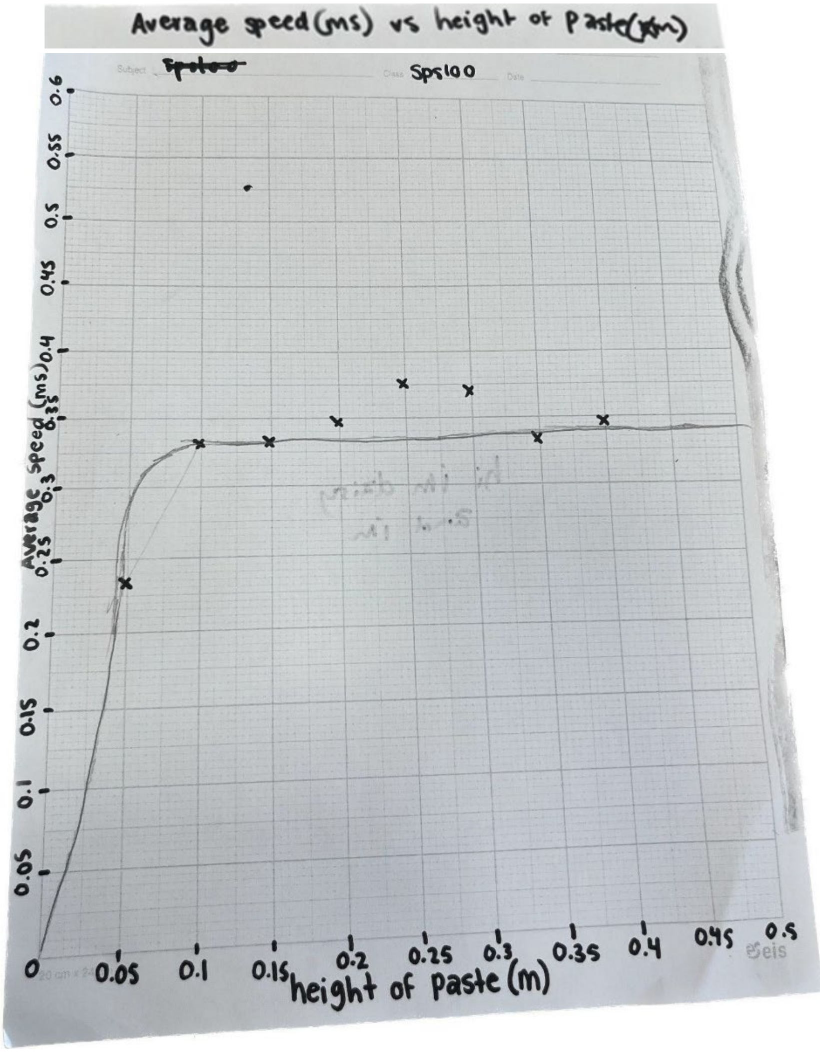


Method -

● Gather a plasticine ball, measuring cylinder, a stopwatch, a metre of string, and some wallpaper paste.
● Tie the string around the plasticine ball.
● Mark sellotape on the cylinder every 5 centimetres upwards starting from the bottom.
● Have the same person drop the plasticine from the top of the measuring cylinder while simultaneously starting the stopwatch.
● Once the plasticine hits the bottom of the measuring cylinder, stop the stopwatch and record the time. Use the string to pull the plasticine out of the measuring cylinder.
● Repeat the previous step three times then find the average.
● Add wallpaper paste up to the lowest mark on the measuring cylinder and time three drops. Repeat for each mark of sellotape until you have three results for all of the marked points.

TASK 2: Gathering Evidence

Paste height (m)	average time (s)		time 1	time 2	time 3		avg speed (m/s)
0.05	0.21		0.16	0.22	0.25		0.238
0.1	0.3		0.28	0.31	0.31		0.333
0.15	0.45		0.38	0.44	0.53		0.333
0.2	0.577		0.54	0.63	0.56		0.347
0.25	0.663		0.63	0.66	0.7		0.377
0.3	0.81		0.81	0.78	0.84		0.37
0.35	1.04		1.3	0.97	0.85		0.337
0.4	1.157		1.31	1.06	1.1		0.346



Conclusion (what does the graph tell you?)

The graph tells me that we had a linear relationship for the average speed and height of the paste. The speed started to accelerate at 0.05m of paste and when we dropped the ball at 0.21. It stayed at a constant speed for most of the graph and accelerated and reached terminal velocity, at 0.25m of paste and at 0.663 speed.

Discussion (How does your conclusion relate to the real life scenario? What are the science ideas involved?)

A real life scenario is skydiving because there are two forces acting in the person. Gravity, is pulling the person downwards while also resisting motion just like the ball falling into the paste. When the person first jumps out the plane the drag will be small and the velocity will be low. As it gets to the middle the speed and the drag will reach the accelrated speed and wont get any higher and then will just decrease again.
However, the difference is the wallpaper paste is thicker so it will have a difference in speed due to its density, which causes more friction and resistance.

Grade: Merit
For Merit, the student needs to explain a physical phenomenon through investigation. This involves explaining how physics concepts and relationships relate to the physical phenomenon, using processed evidence. This student has explained the motion of a balloon by: • correctly identifying the time axis on the graph and concluding the larger balloon takes the most time • explaining this unexpected result using a cause-and-effect chain. The larger balloon has a larger profile, which causes more drag • identifying the apparent fault with the bar graph's X-axis, and explaining this in terms of the values of balloon width. For Excellence, the student could discuss the observed effect of balloon size on time taken with a clearer flow of ideas. The final three paragraphs make suitable points and use the collected data, but the contradictory statements mean that understanding is not clearly shown.

Merit

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The AIM of the experiment is:
to see how the propulsion of a balloon is affected by how inflated it is.

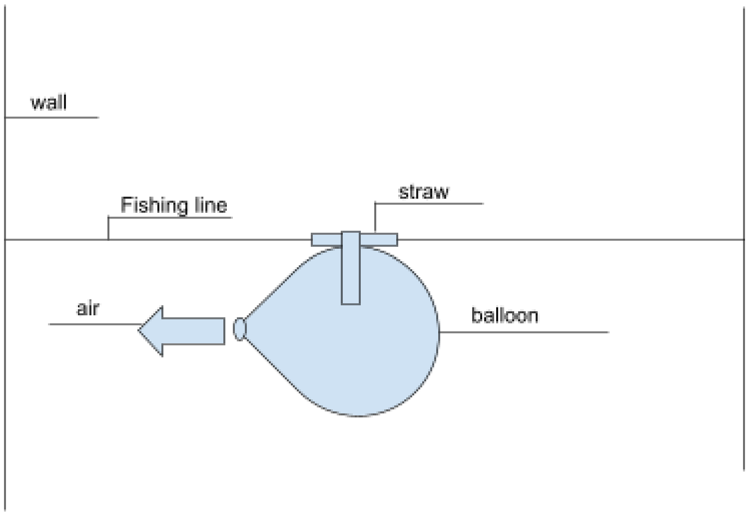
Which is the INDEPENDENT VARIABLE (the one that will be changed)?
How much air is in the ballon(ballon width once inflated)
What range of values will be used?
15 - 25 - 30 cm wide inflated balloons

Which is the DEPENDENT VARIABLE (the one that will be measured)?
The time it takes for the balloon to travel along a fishing line.

Which other variables will need to be CONTROLLED so that they don't affect the results? For each one explain why and how it will be controlled.
Balloon tension needs to be controlled, this can be solved by using a fresh balloon each time. We also need to prevent wind from additionally propelling the balloons, this is solved by conducting the experiment indoors.

Use the information from the previous questions to write a method to carry out your investigation. Your method must have enough detail to enable another student to repeat the experiment.
Measure out a length of fishing line and tie one end to one end of the room. Thread a straw onto the line and tie the other end to the opposite side of the room. Blow up a balloon until it is 15 cm wide and hold the hole shut. Tape the balloon to the straw and release the balloon at the same time as starting the stopwatch. When the balloon reaches the other side, stop the timer and record the time in a table. Repeat with a balloon that is 25 cm wide and again with a 30 cm wide balloon. Repeat experiment 2 more times for each size balloon.

Draw diagrams if appropriate and make note of equipment needed.



Fishing line
drinking straws
9 balloons (minimum)
Celotape
Scissors
Stopwatch

TASK 2: Gathering Evidence

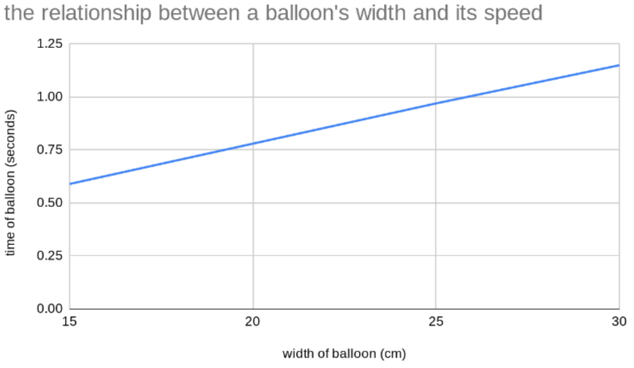
Raw data.

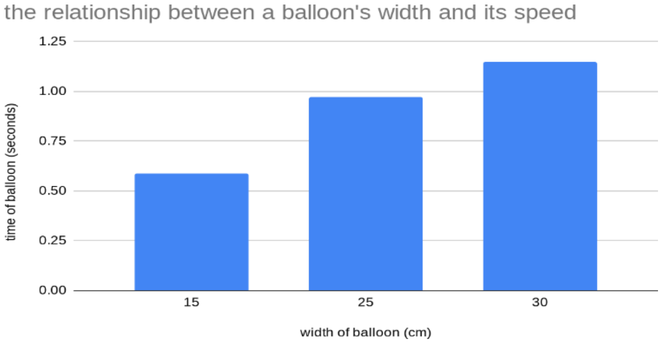
0.57 s (15 cm)
0.68 s (15 cm)
0.52 s (15 cm)
0.91 s (25 cm)
1.10 s (25 cm)
0.91 s (25 cm)
1.17 s (30 cm)
1.20 s (30 cm)
1.08 s (30 cm)

Table of results:

	Trial 1	Trial 2	Trial 3	Average
Small (15)	0.57 s	0.68 s	0.52 s	0.59 s
Medium (25)	0.91 s	1.10 s	0.91 s	0.97 s
Large (30)	1.17 s	1.20 s	1.08 s	1.15 s

TASK 3: Analysing Evidence.



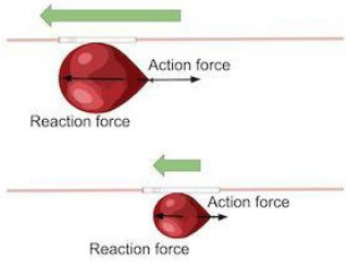


Conclusion (what does the graph tell you?)
The graph says that as the size of the balloon increases so does the time taken to reach the end of the fishing line, this was because the larger balloons had a larger profile so their drag was greater and they didn't cut through the air as fast as the small balloon.

Evaluation (Include validity of method and reliability of data; what went well and what didn't go so well?)

The data isn't very precise, this is due to human error; the time was offset by the timer person's reaction speed for stopping and starting the timer. We also couldn't properly measure the balloons width due to them being spherical. In the bar graph it appears that the larger balloon's speed difference fell off, compared to how slow the medium balloon was to the small one. This was due to the fact the largest balloon is only 5 cm larger than the medium balloon, which is 10 cm larger than the small balloon. This was because the largest balloon was likely to pop if i had inflated it to 35cm wide.

TASK 4: Show your understanding of the relevant physics concepts involved in moving an object with air pressure.
Discussion (How does your conclusion relate to the real life scenario? What are the science ideas involved?)
A balloon's motion is caused by the air pressure in a balloon trying to equalize to the air pressure outside of the balloon, this causes the air to rush out and due to Newton's third law apply an opposite force to the balloon, another example of newton's third law is how the force of gravity upon an object is resisted by an opposite force generated by the ground.
The pressure in a balloon is generated by the elasticity of the balloon trying to return it to its resting width. The force created compacts the air, according to Newton's third law this creates an opposite force preventing the balloon from shrinking. This makes the air inside the balloon at a greater pressure than the air outside the balloon.
In my experiment I observed that as the size of a balloon increased so did the time that it took to travel along a string this was due to the increased drag.
As the balloon's size increases the surface area and profile also increases, because of this they hit more air particles and experience more drag. This can be observed in my experiment in how the 30 cm wide balloon was almost twice as slow as the 15cm wide one.
A real world example of this is in how as the fuel tanks size of a rocket increases it experiences more drag. Scientists get around this by making the tanks longer and skinnier, this decreases the profile and increases the speed by lowering drag.
In addition to increasing drag a higher profile and larger surface area can also increase the effect of wind on an object. larger objects are more likely for air particles to hit these air particles apart there speed onto the balloon, this explains why the largest balloon's speed isn't as slow as expected. Small changes in the wind could potentially have impacted the data of the larger balloons because of this.



Grade: Excellence
For Excellence, the student needs to analyse a physical phenomenon through investigation. This involves integrating processed evidence with a discussion of relevant physics concepts and the relationships involved. This student has analysed the falling of a muffin case by: • calculating the gradient of the graph, which shows capable data processing • clearly relating the findings of the investigation to sky diving in the conclusion • discussing how reaching terminal velocity takes the same time for each fall height, so the overall speed increases with height.

Excellence

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Purpose of investigation:
To find out how the <u>height</u> at which a muffin case is dropped affects the <u>time taken</u> to reach the ground and how this can be applied to the context of falling from space

Prediction: **I think that….**
I think that the greater the height the muffin case is dropped from, the greater the time taken to reach the ground will be.

Which variable will be changed? (This is the independent variable)
Height at Which Muffin Case is Dropped (meters)

How will the independent variable be changed?
By ~~increasing the decreasing~~ increasing the release height (Height at Which the Muffin Case is Dropped).

Do some trials to decide on a suitable range of values for this variable (at least 5 values)
~~..., 0.6m, 0.7m, 0.8m, 0.9m, 1m~~

1.2m, 1.4m, 1.6m, 1.8m, 2m

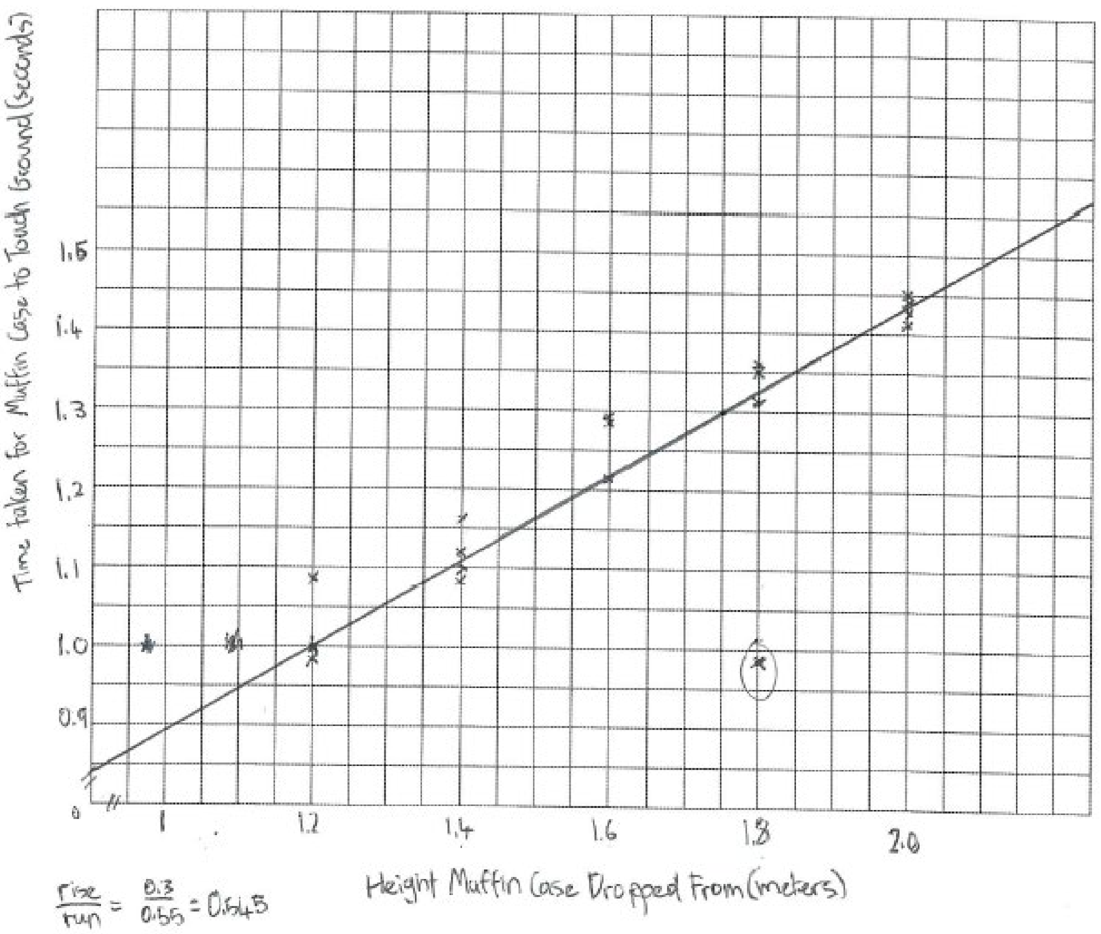
Which variable will have to be measured or observed in order to get some data or information from the investigation? (This is the dependent variable)
Time Taken to Reach the Ground (seconds)

How will the dependent variable be measured or observed – be clear on how you measured and **include units.**
The time Taken to Reach the Ground will be measured in seconds with a stopwatch. The stopwatch will be started on release and stopped on ground impact of the muffin case.

Method: Now use the information on this planning sheet to write a detailed step-by-step method. A diagram could be used. <u>This should be in your own words and different from others in your group.</u>

Drop Height	Trail 1	Trail 2	Trail 3	Trail 4	Averages	speed
1.2m	1.00 sec	1.00 sec	1.09 sec	0.97 sec	1.015 sec	?
1.4m	1.12 sec	1.10 sec	1.08 sec	1.12 sec	1.105 sec	?
1.6m	1.22 sec	1.28 sec	1.28 sec	1.29 sec	1.2675 sec	?
1.8m	0.97 sec	1.35 sec	1.31 sec	1.36 sec	not including OL 1.34 sec	?
2 m	1.43 sec	1.41 sec	1.44 sec	1.45 sec	1.4325 sec	?

Relation between Time Taken for Muffin Case to Touch Ground and Height Muffin Case Dropped From



$\frac{rise}{run} = \frac{0.3}{0.55} = 0.545$

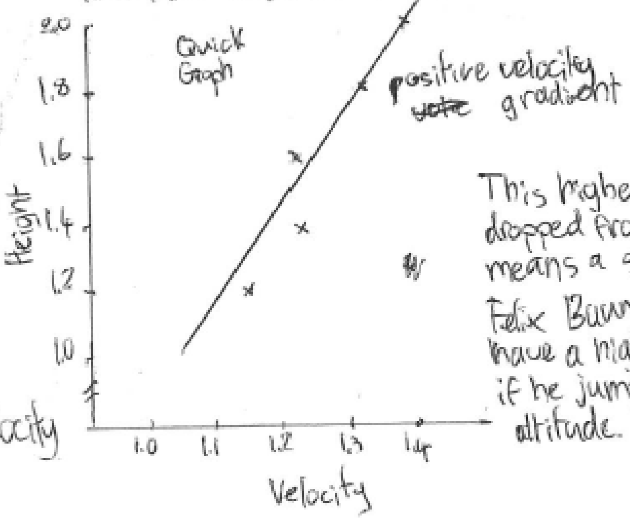
Write a **conclusion** that links to the purpose and to the context. Consider your results, graph, gradient of graph (gradient = rise/run). Do further calculations using the data to double check what the gradient shows. Relevant formula: v=d/t

In conclusion, my prediction was ~~right~~ correct, as the graph shows a positive (0.545) trend towards Time Taken for Muffin Case to Touch Ground in relation to Height Muffin Case Dropped From. This means the greater the Height the Muffin Case Dropped From is, the greater the Time Taken for Muffin Case to Touch Ground will be, which was my prediction.

This would therotically mean a skydiver such as Felix Baumgartner would take longer to reach the ground if they jumped from a higher altitude.

Height	Velocity d/t
1.2m	1.182m/s
1.4m	1.267m/s
1.6m	1.267m/s
1.8m	1.343m/s
2.0m	1.396m/s

← Height Muffin Case Dropped From (m) / Time Taken For Muffin Case to Reach Ground (s)



This higher velocity when dropped from a higher height means a skydiver such as Felix Baumgartner would have a higher average velocity if he jumped from a higher altitude.

Felix Baumgartners maximum terminal velocity was 1357 Km/h.

Science Ideas: Write an explanation of your results in terms of the physics ideas involved (what is the science to explain your observations/results that links to the purpose)
The physics concepts involved are **motion & forces.** Explain these concepts and how they have resulted in your conclusion, include terminal velocity concepts, link to your data AND you could do further calculations.

The muffin case takes longer to reach the ground when dropped from a higher height because it encounters more air resistance force in total, ~~slowing~~. Although the velocity is relatively the same, ~~more~~ the muffin case has further to fall, which means it will experience more air resistance in total.

Averag Velocity only increases with height dropped because it has more time to fall at maximum speed, or terminal velocity. The muffin case takes a set amount of time to accelerate, and then reaches max speed, ~~The~~ time taken to reach terminal velocity and time at terminal velocity are added up and divided by the distance/height. This means the difference in velocity will be smaller and smaller as the height the muffin case is dropped from increases, although ~~it will always~~ velocity will always increase as height increases.

As the muffin case is at the top of the height it will be dropped from, it has maximum gravitational potential, and no force is acting on it, therefore there is no motion. The tension force of the hand and the weight force of the muffin case is equal, therefore the forces are balanced. The net force is 0.

When it is released, the tension force is elaminated and the weight force of the muffin case causes it to move downwards.

As it moves downwards, the surface area of the muffin case causes air resistance force, which increases as speed increases. as more air molecules obstruct it per amount of time as it moves faster. At this point the forces are unbalanced, as the gravitational force is larger than the air resistance force, meaning the net force is not 0 and the muffin case is accelerating.

As it decends further, air resistance force increases until it equals the weight force, and the forces are balanced again. This is called terminal velocity. Terminal velocity occurs when the air resistance force equals the weight force of an object. It means the object is at maximum speed.

The muffin case then decends at terminal velocity until it contacts the ground.

When the muffin case touchs the ground, all gravitational potentional energy has been converted into kinetic energy, and the muffin case is not in motion because the push/surface force of the ground equals the weight force of the muffin case, meaning the net force is 0 and the forces are balanced.

All of these concepts apply to a skydiver such as Felix Baumgarther skydiving, although he jumped at a very high altitude, where the air resistance is much less. This means he would accelerate much faster relative to the air lower down. He would also achieve a higher terminal velocity in the thinner air for the same reason, but as he decends it would decrease, and drastically increase as the surface area was increased with a parachute.

To produce reliable and accurate results, we made sure to keep controlled variables as consistent as possible. The same equipment was used throughout, and the person doing a task did that task the whole time.

The biggest concern was the variation in the shape of the muffin case. As it is held, the sides are compressed, altering the surface area and therefore the resulting air resistance.

The best solution to this would be to use a consistent mechanical dropper.

We collected one outlier, which I discarded. It was not necessary to replace this as 3 trials are enough to get an accurate average.