Creating Science – Bounce Master and Maths in Science

So exactly how do we measure 'bounciness'?

Maths is the 'language' of science, in a study into things that bounce. ***#CreatingScienceBounceMaster***

Suggested outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science understanding

- Physical sciences 7: Change to an object's motion is caused by unbalanced forces, including Earth's gravitational attraction, acting on the object (ACSSU117).

Science inquiry skills

Science inquiry skills, for example, year 7:

- Planning and conducting 7: Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125). Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126).
- Processing and analysing data and information 7: Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS129) Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130).
- Evaluating 7: Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS131) Use scientific knowledge and findings from investigations to evaluate claims based on evidence (ACSIS132).

Science as a human endeavour

- Nature and development of science 5: Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena

Cross Curricular Outcomes

- Year 7, real numbers: Express one quantity as a fraction of another, with and without the use of digital technologies (ACMNA155).

Science vocabulary words

Tier 1 (Everyday words) – ball, bounce

Tier 3 (Specialised vocabulary)

- Friction - A force which pushes in the opposite direction of the way something is moving. It usually turns that motion into heat.
- Gravity - A force which attracts two objects together, such as your body and the floor. Gravity is *so weak* we hardly notice it every day, unless we are next to something REALLY MASSIVE – like the planet earth, for example.
- Coefficient – a multiplier or factor that measures a particular property.

Warning

- Bouncing balls are generally safe, but present a choking hazard for small children and a blunt trauma injury hazard for those who aren't careful. Please warn children and act appropriately.

Preparation

- A selection of balls, including tennis or high bouncing balls. Students might be invited to bring a ball from home if you feel you can manage appropriately.
- Measuring tape, enough for one per student. Tape rulers are particularly effective. If you lack rulers, mark off the walls (or perhaps more appropriately, a poster on a wall) with 100cm in 1 cm increments.
- Print out or have students draw up a results sheet from the back of this document. You might prefer to have them embed it in a spreadsheet (at www.CreatingScience.Org)
- A hard floor (such as wood or concrete) will get the best results.

Class preparation

Looking forward to seeing you all soon. As preparation, you might like to think about a special kind of movement today – bouncing!

If you'd like, and if you think you can be safe and sensible with it, you can bring along your favourite ball or bouncing object.

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students' questions can and should guide student learning, more material is presented for your convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

This activity is difficult for this group, but may still work if one ball is used by small groups.

Middle:

Well suited to this group, students can practice group roles, and gain an appreciation of maths.

Teen:

While initially entertaining, students will need to be engaged with higher order thinking.

- What else are coefficients used for?
- What does this simple activity teach us about creating scientific knowledge? (Averages, using mathematics to solve problems, multiple trials, precise measurements, etc.)

Learning Intent (student friendly)

'We are learning to' (WALT) use maths to find answers in science.

Success criteria

'What I'm looking for' (WILF) students to accurately and carefully calculate the co-efficient of bouncing for their selection of balls.

Student learning goals

Help students make a self-monitored learning goal for this lesson, such as 'find out how to tell if one ball is more bouncy using science', or 'find out exactly how much more high bouncing balls will bounce compared to soccer balls'.

Evidence of learning

How will you know when the learning goal is achieved? What EVIDENCE do you have that your students have met or exceeded the learning expectations? For example, can they present you with the table in the appendix, or use the coefficient of bouncing to solve the riddle of Bounce Master?

Engage

- ⇨ Make sure all students write down any questions they may have generated during this phase regarding the topic for today.

Invitation (older levels):

- ⇨ Can you find the exact bounciness of a ball?

Invitation (younger levels):

"We have a problem. **Bounce Master the very bouncy super hero** has to get into a burning building to save people's lives (he's also fireproof). But there aren't any ladders around, and the building is already heavily on fire. Everyone has run up to the roof, 20 meters up, and they are safe for now."

"Thankfully, the building across the road isn't burning. It's 10 stories high, with each story being 10 meters high. It's a very tall building."

"What window on the tall building should Bounce Master use in order to make sure he bounces right into the 10 meter window on the burning building?"

Explore

Allow students to muck around with the balls, and to toss around a few ideas.

After a while, suggest:

- ⇨ PROVE WHICH IS THE BOUNCIEST BALL. If you use maths and it tells you how high the ball will go in one meter, will you be able to tell how high the ball will go in 10 meters?
- ⇨ Remember, smashing the ball on the floor won't help. We need an exact measure so that our bouncy hero can save the day.

Explain

Explain:

The "bounce coefficient" can answer these questions for us. It is defined as how 'bouncy' a ball is, and is calculated by taking the height of a ball's bounce, divided by the height from which the ball was dropped.

So;

$$\text{Bounce coefficient} = \frac{\text{Height of the ball's bounce}}{\text{Height the ball was dropped from}}$$

We can use this coefficient to calculate a whole range of things:

- We can know how high a ball will bounce if we know how high it fell from.
- We can know the height an object fell from if we know its bounce coefficient and its final bounce height. This is regularly used in crash investigations.
- It can help us know how fast cars were originally moving in a car crash, and we can tell if someone was in the wrong lane, or speeding.

Once you know the *coefficient* of anything, you can compare two numbers very quickly and easily.

Experiment:

Using three balls, try to determine the bounce co-efficient of each of them. Use the average of five bounces (or more, if you prefer) to try and get a more accurate answer.

You could try:

1. Tape a 1 meter ruler or tape measure onto the wall.
2. Drop the ball from 1 meter (100cm) – don't shove, just release.[1] Remember when dropping the ball, its base should be level with the 100cm mark.
3. Allow one or more observers to try and measure how high the ball bounced back up to on its first bounce only (and not the other bounces). The big trick here is to make sure you're accurate! You MUST measure the bounce height from the bottom of the ball as well, not the top.
4. Record your results on the table in the appendix.
5. Repeat the experiment 5 times
6. Then take the average of the 5 results in order to try and get a more accurate answer.
7. Repeat the entire experiment from point 1 with at least 2 more balls. Find out which ball was the bounciest.

Find the coefficient of bouncing

Take the first of your results, then:

$$\text{Bounce coefficient} = \frac{\text{Average height of the ball's bounce}}{\text{Height the ball was dropped}}$$

So if you first ball averaged 80cm, you will do;

$$\text{Bounce coefficient} = \frac{80}{100}$$

In other words, average bounce (80cm) divided by drop height (100cm) gives you a bounce coefficient of 0.8. Do this for each of your three balls.

[1] It does not have to be a meter exactly, but it makes the calculations a little easier. If you find students get confused with all the jumping decimals, don't start at 100cm. where to start instead?

Solving Bounce Master's problem

Now in order to find out the answer to Bounce Master's problem;

He needs to get up 10 meters to reach the second story.

1. For each ball in your first experiment, find the co-efficient of bouncing.
2. To calculate how to get up 10 meters, divide 10 by your coefficient of bouncing.
3. The result is how high Bounce Master needs to be on his original drop.

So a super high bouncing ball with a co-efficient of bouncing of 0.8 will need a launch height of 12.5 meters to reach the second story of the burning building. (Maybe he can stack a few tables up to get those extra 2.5 meters while standing on the second floor of the second building).

While if Bounce Master was about as bouncy as your average soccer ball, 0.2, then he'd need to jump from 50 meters – or the 5th floor of the second building, to save those poor people.

Note:

Balls can never bounce right back up perfectly to their original height. But that doesn't mean the energy is 'lost' – it is only transformed into things we don't need right now, such as:

- Heat – balls heat up when they bounce.
- Sound energy – if there was no sound, the ball would bounce higher.
- But mostly – air resistance. Pushing all that air out of the way really slows the ball down!

But a ball with perfect elastic bounce (diamonds come close) in a vacuum and with a gravitational field might keep bouncing forever!

Elaborate

Try:

- How was the bounce affected when you bounced the ball onto another object, such as a carpet? [Some of the energy is absorbed by the carpet, resulting in a lower bounce.]
- Place a tennis racquet under the ball – does it improve or weaken the bounce co-efficient? If it weakens it, why do we use them at all? (Perhaps because while concrete has a better return, the main factor in tennis racquets is weight. We need them to be as light as possible.)

Non-elastic collisions

Of course, this experimental activity requires what we call 'elastic collisions' – collisions where there is bounce. What about non-elastic collisions, where there is no bounce?

Imagine trying to do this activity with a ball of playdough or a balloon full of flour. The coefficient of bouncing is almost 0 – there is no bounce, it just squishes onto the floor. But the science of non-elastic collisions need not end there. We end up measuring the amount of deformity an object acquires from the collision. So once again, there's plenty of science to try out here!

Evaluate

⇨ Review with students what they felt they learnt from this lesson. Did they have any questions at the start that they feel were answered?

Success criteria

⇨ Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective to see how we did. Ask:

⇨ Did you achieve your learning goal?
⇨ What did You learn?
⇨ What worked to help you achieve it?
⇨ What might you do better next time?
⇨ (If needed) where can you go for extra help or information?

Assessment

Prior learning:

Ask:

- How can fractions help us?
- Do students know what a coefficient is?
- How can we measure how bouncy a ball is?

Formative:

Help students to measure a ball's bounce height, calculate an average, and generate a co-efficient. Discuss with students in each stage their understandings of these 3 important steps.

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do. Did you know the coefficient of bouncing (also known as the coefficient of restitution) has been used to help measure everything from new scientific tennis racquets, to auto collisions?

Creating science

Science understanding

As we explored the motion of various balls due to gravity and their elastic collision with the floor, we saw that;

- Physical sciences 7: Change to an object's motion is caused by unbalanced forces, including Earth's gravitational attraction, acting on the object (ACSSU117).

Science inquiry skills

As we were using the following skills;

- Using measuring to create scientific knowledge.
- Using maths to create an average and a co-efficient.
- Using a co-efficient to answer a hypothetical scientific question.

We had the chance to develop the following skills;

- Planning and conducting 7: Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125). Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126).
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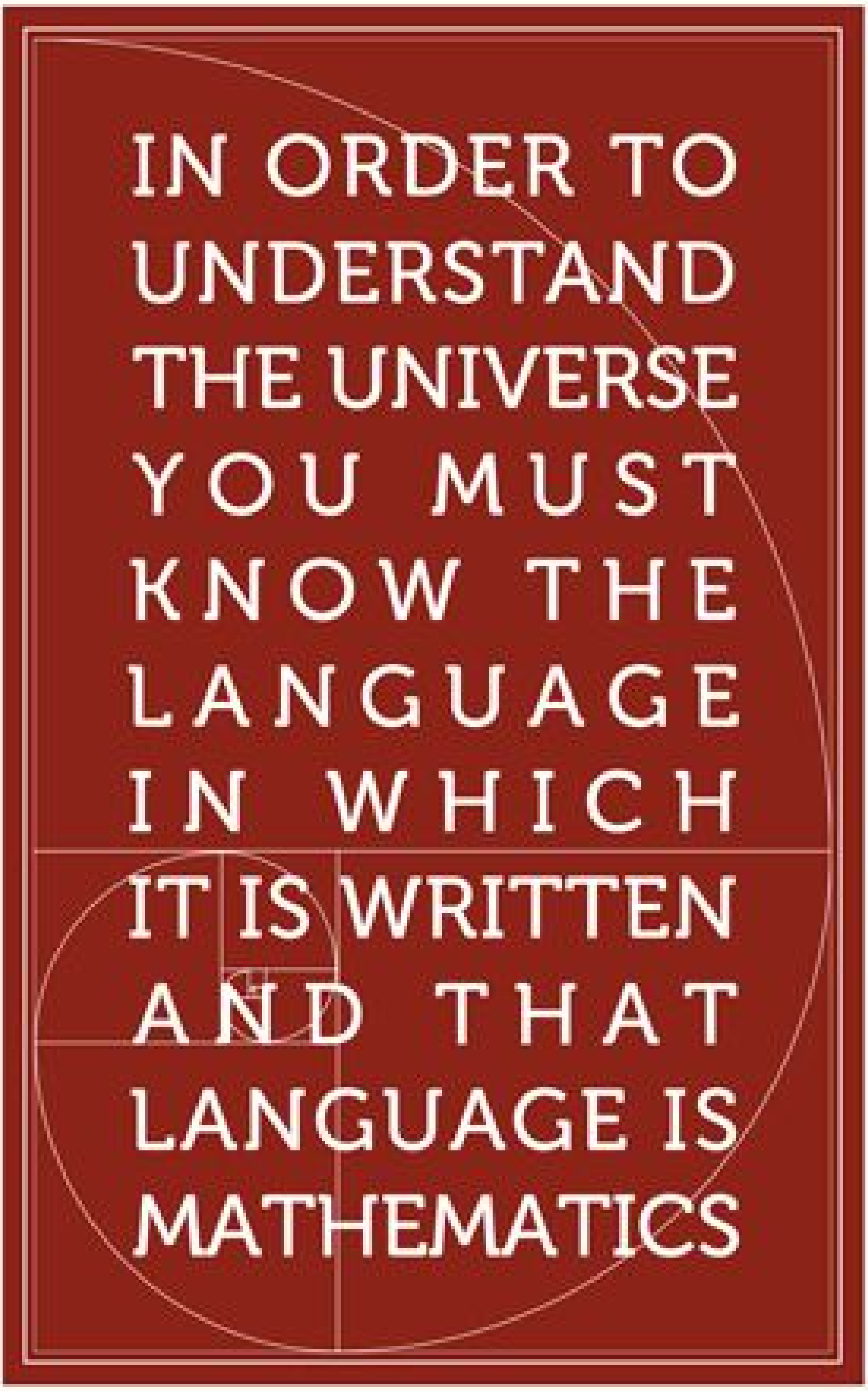
- Evaluating 7: Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS131) Use scientific knowledge and findings from investigations to evaluate claims based on evidence (ACSIS132).

Science as a human endeavour

In using maths to answer science questions, and in developing the coefficient of bouncing, we saw that;

- Nature and development of science 5: Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena

Appendix – Inspirational Posters on Maths



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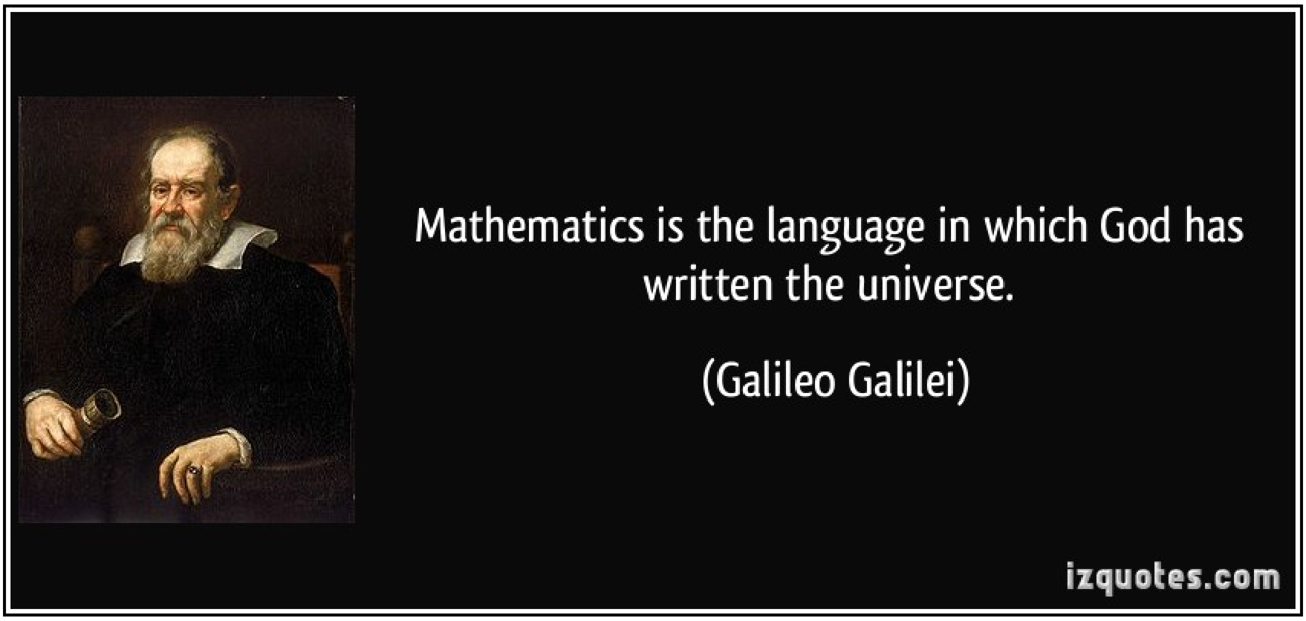

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Extra activities

Three tricks with high bouncing balls

There is a lot more to bouncing a ball than you might think. Here are three interesting ways you can make things bounce.

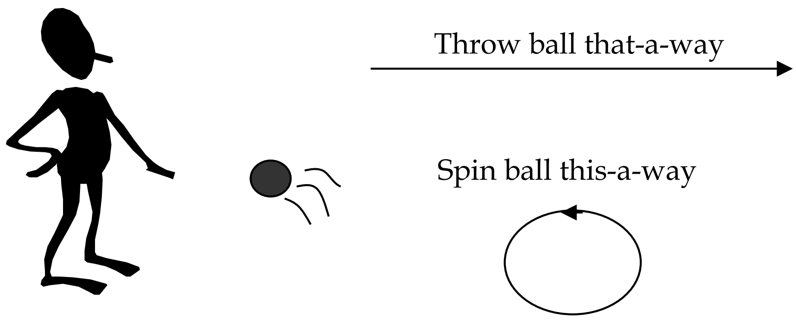
Aim:

- To explore factors such as inertia, elastic potential energy, and friction on motion
- Energy and change 1.1 "Students collect information about the ways that objects of different shapes and sizes [and orientations of spin] move."

Description: There are three experiments in this series.

1/ <u>The incredible returning bouncing ball.</u>

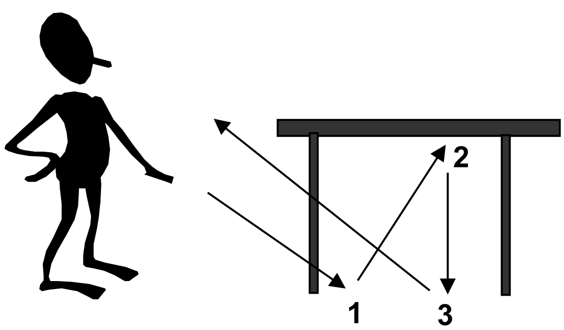
Simply toss a ball just in front of your feet, but spin it with your hands in the opposite direction. With enough spin you can throw the ball well away and it bounces right back to you! This is a very common trick with hula hoops as well.



Which way does the ball end up going?

2/ <u>The amazing returning high bouncing ball.</u>

A similar trick, you can get a high bouncing ball to return to you by getting it to bounce, and thus spin, under a table in a certain way. Three times is all that you need. By the third bounce it will be spinning back towards you just like in activity 1 above.



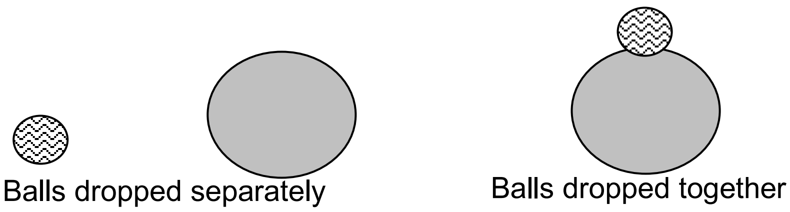
3/ The astonishing helper bouncing ball.

Be sure to use this as a demonstration well away from the students. The balls can bounce surprisingly high!

For this trick you need two balls, one preferably larger than the other.

Show the students how the balls bounce separately. Neither will return to the height it was originally dropped at.

Now place the smaller ball on top of the larger ball and try to drop them at the same time. The results of the combined bounce might surprise you!



3 Tricks – how they work:

1/ As the ball hits the ground, it pushes away from the ground in the direction of the spin. This is due to something called friction, which is the force between a moving object and whatever it touches. You can choose which direction a ball will bounce in by changing the direction it is spinning it.

2/ Friction is at it again! The high bouncing ball changes the direction it is spinning in each time it strikes a surface. By the third time it is spinning right back in the direction it started in.

3/ Part of the bounce from the large ball is passed directly to the smaller ball, making it bounce much higher. In exchange, the bigger ball will not bounce so high. Did you notice?

Extensions

- Try spinning a high bouncing ball as in experiment one, and letting it bounce as often as it likes. What happens?
- Will the table ball work if the ball bounces 4 times? How about 5?
- What happens if you trade places of the large and small balls from experiment 3?

Tips from the Masters

Spread out around the room for lots of bouncy bounciness!

Use a ruler, and get down low to go!

Table of results:

Drop a ball from 1 meter up. No throwing! Record all answers in the same unit, such as Centimetres.

	Ball 1	Ball 2	Ball 3
Ball:			
1st result			
2nd result			
3rd result			
4th result			
5th result			
Average			
Coefficient of bouncing (average result / initial height of the drop)			
% bounciness *(coefficient times 100)*			

Final height = initial height *divided by* coefficient of bouncing

Initial height = final height *multiplied by* coefficient of bouncing

???Did maths help you to create better scientific knowledge today???