Why do objects slow down? The teacher guide

Whybricks
Giving physical science form

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About Whybricks

Whybricks is an education-focused construction system consisting of 2,100 pieces (210 pieces per student). Each Whybricks kit contains everything needed to enable 10 students to work individually.

Each Whybricks kit contains interlocking building blocks, beams, pegs, gears and other parts. The individual Whybricks pieces are designed with studs and holes which are compatible with any LEGO brick compatible building system.

Why use Whybricks?

The Whybricks kit, along with the supporting lessons, can help students tangibly access topics that can otherwise feel abstract. Whybricks allow students to explore physical science and engineering phenomenon in a hands-on and engaging way. By enabling students to explore topics through physical activity, students engage in kinaesthetic learning, allowing them to experiment with productive trial-and-error and bridge potential gaps between theory and practice.

The Whybricks lessons use the Whybricks kit to help to support or elevate understanding for any type of learner. The Whybricks kit offers a way to bring hands-on learning in as a functional part of each Whybricks lesson plan.

Managing Whybricks in your classroom

Whybricks offers educators flexible teaching options. Both the Whybricks kit and lessons are intentionally versatile to allow teachers the freedom to implement the materials however best suits their classroom's needs.

The components of each Whybricks kit are supplied with the intention of being a 'pool of parts' for the teacher to use as you see fit. The parts can be organised and stored as best suits your classroom and students. Some ideas for managing the Whybricks kits in your classroom include:

- Create individual 210-part student kits for each student.
- Make up packs with just the parts needed for a specific lesson activity or project.
- Make 'STEM boxes' with instructions and pieces for a challenge for rotation stations.

- Divide up the full kit, arranged by part type, into a storage tray-style storage system, allowing students to find and use the parts they need.
- Provide only a selection of parts in a mixed pack for semi-open and open-ended projects, limiting students from being overwhelmed or distracted by other parts and providing an engineering constraint.
- Keep all the parts mixed together in a single pile free-for-all.

About the 'But, Why?' lessons

This lesson is a *But, Why?* Whybricks Lesson. What does that mean?

Try this.

Ask 10 students the question 'why do people use wheelbarrows?' You will likely end up with 10 versions of the answer 'because it makes it easier.' And they are right, of course!

Your students already know a lot about how the world works. They know that when they let something go, it falls down. They know that riding a bicycle is faster than walking. What they might not know, or may not be able to articulate, is why these things are true.

Now imagine the conversation again:

> You: Why do people use wheelbarrows?
>
> Student: It makes it easier.
>
> You: It makes what easier?
>
> Student: ... Doing... the work. You know, carrying heavy stuff, or big stuff.
>
> You: But, why?

These lessons will help you flip the script

The *But, Why?* Whybricks Lessons are designed to help teachers transfer agency over learning to students. These lessons help you take your students on a learning journey by asking them 'why?' and supporting them in discovering and presenting their answers using sound engineering and scientific practices.

These Whybricks investigations start by getting students to communicate what they already know about observable phenomenon. By asking students 'why?' up front, the Whybricks investigations help educators determine and celebrate what students already understand. This intuitive understanding is then built upon inside the investigation. Each lesson supports students in growing their grasp of the reasons that underpin the 'why' of what they have already discovered.

The *But, Why?* investigations help students invest in their learning through active and hands-on sciencing (because science is a verb now!) and engineering. The 'why' question format drives the inquiry nature of each investigation, exploring different aspects of physical science and engineering.

Pedagogy approach

The pedagogy behind the *But, Why?* Whybricks lessons set is to deliver physical science education holistically. Through the investigations, students will:

- encounter facts (for example, Newton's second law is mathematically expressed as F=ma),
- exercise a scientific mindset (for example, making observations by answering 'what do you notice?' and developing questions by considering 'what do you wonder?'),
- participate in scientific and engineering practices (for example, by planning and carrying out an experiment or by developing and iterating a design), and
- make real-world connections between the world around them and the material they are learning.

The methodologies used in the investigations are inspired and informed by:

- The PQRST approach developed by DaNel Hogan and Brooke Meyer https://stemazing.org/pqrst/
- The inquiry in the classroom approach as codified by Trevor Mackenzie https://www.trevormackenzie.com/

With great appreciation and heart-felt thanks for your collaboration for constructive disruption.

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The *But, Why?* Whybricks Lesson Set is comprised of the student materials (including the *But, Why?* lesson activity Whysheets, Notice and Wonder sheets and WOW sheets) and the teacher guides. The collection is licensed under a Creative Commons Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)[1].

Using the guides and the lessons

Each *But, Why?* Whybricks investigation is slightly different. As every investigation explores different physical science and engineering topics, the layout and activities of each one differs to best enable meaningful learning to be achieved. There is no set order in which the investigations should be explored and no wrong-way of adjusting an investigation to suit your students or curriculum.

This guide offers support for educators to get the most out of this lesson.

Overview of the student materials

Each *But, Why?* Whybricks investigation is intended to be student-centred and led. With the exception of the teacher guides, the educational materials are all 'student materials' and are designed for independent use by students.

The student materials for this lesson can be downloaded from https://whybricks.com/lesson-set/but-why/

There are three types of interrelated printable student materials:

- Whysheets
- Notice and Wonder sheets
- WOW sheets

An overview of each type of document follows.

About the Whysheets

The core of each *But, Why?* Whybricks investigation is its Whysheet. Much more than a worksheet, a Whysheet is the students' (and educators') guide for the investigation.

[1] Creative Commons licence information can be viewed at http://creativecommons.org/licenses/by-sa/4.0/

Every Whysheet starts with the 'why' question the investigation is centred around. Students answer the question to the best of their ability, drawing on what they already know. The goal isn't to get it 'right' but to codify what they already understand and, over time, get them to think about what they don't understand as well.

The Whysheet will then walk the students through the investigation step-by-step.

Any WOW sheets related to the investigation will be referenced in the Whysheet as will suggestions for when to use the Notice and Wonder sheets. If there is a set Whybricks build, step-by-step build instructions will also be included as an appendix to the Whysheet. You can also encourage students to improve on the set builds, further exploring and applying aspects of physical science and engineering.

The Whysheets, along with the Notice and Wonder sheets, are designed to capture learning evidence as it happens during the investigation, rather than be a 'now that you have finished everything, write in the correct answer' style worksheet. Encouraging students to view the Whysheet as their tool to help them through the investigation will help them take ownership over their learning.

About the Notice and Wonder sheets

The Notice and Wonder sheets are templates designed to work alongside any *But, Why?* investigation. These sheets offer places for students to note observations 'I notice …' and capture questions 'I wonder …' throughout the investigation. The Whysheets will indicate key opportunities in an investigation when students will benefit from making notes in a Notice or Wonder sheet, but students should feel free to use these sheets throughout their learning journey, especially for capturing new questions they begin to wonder about as they progress.

Along with the Whysheet, the Notice and Wonder sheets form an important part of capturing learning evidence and empowering student agency in each investigation. All of the Notice and Wonder sheets serve the same purpose, but different versions are available to offer educators flexibility in adapting these to their students' needs.

The Notice and Wonder sheet set includes an educator's overview and recommendation section with additional information.

About the WOW sheets

The WOW in the WOW sheets stand for 'Why? Oh, Whoa!'.

WOW sheets are a way of inserting teaching into an investigation flexibly. For example, you might choose to provide copies of the WOW sheets for students to read in-depth or just reference to find the answers they need. You can also replace WOW sheets with your own lecture or other fact-delivery method on the topic, explaining and exploring as deeply as you see fit.

These sheets are basically reference cards. Each WOW sheet contains information about a specific topic or fact. The WOW sheets help students to discover and understand key information, enabling them to apply what they learn back into the investigation. Examples of the content covered in WOW sheets includes definitions of terms (e.g. 'What is mass?'), explanations of facts (e.g. Newton's third law) and formulas in context (e.g. calculating acceleration, part of the 'What is acceleration?' WOW sheet).

WOW sheets can be used in several ways. You can use them to help guide class-wide explanation sessions or allow students to access them independently when and if they need the information. The WOW sheets can introduce concepts, serve as quick 'refresher' reference cards or be used retrospectively to demonstrate broader applications of elements encountered inside an investigation.

The Whysheets will indicate key moments in an investigation when students may benefit from using a specific WOW sheet. You may also find it helpful to have the WOW sheets available for students to access at any time.

Overview of the teacher guide

This teacher guide offers overview information plus per-investigation support for educators to get the most out of each lesson.

Remember that the *But, Why?* lesson set is intentionally flexible. There is no set order in which the investigations should be explored. Likewise, while the teacher notes offer additional support for educators, by design they are not overly prescriptive.

The *But, Why?* investigations aim to inspire students to 'think like a scientist' or 'think like an engineer'. Rather than simply explaining how something works, the lessons encourage active participation in learning by conducting experiments and problem-solving. Armed with these experiences, the students are the ones doing the sense-making.

As you might expect, trial-and-error is an inherent part of this approach. To get the most out of their Whybricks lesson, you should support your students as they work through productive struggles without jumping in and 'saving them' from these exciting learning opportunities. Give students a chance to impress you, and themselves, with the thinking they can do. However, you know your students best! Always feel free to adjust any investigation to suit your students or curriculum as you see fit.

For each *But, Why?* investigation you will find teacher notes specific to the investigation that include:

- An overview of the investigation
- A list of the topics covered
- A list of the WOW sheets needed (both those explicitly noted in the student Whysheet plus any additional recommendations)
- Recommendations for running the investigation
- Additional notes specific to the investigation (including sample answers to specific Whysheet questions)

Love these lessons? Hate them? Have an idea for a lesson activity?

The team behind Whybricks would love to hear from you! You can share your feedback and ideas with us through the contact form on our website at https://whybricks.com/support/contact-us/

Why do objects slow down?

Overview

This project is centred on Newton's three laws of motion. Students first dive deep into Newton's first law of motion (inertia). A basic introduction to Newton's second law of motion (**F**=*ma*) follows as students observe the result increasing force has on motion. Finally, students observe Newton's third law of motion (for every action, there is an equal and opposite reaction).

Topics covered

- Newton's laws of motion
- Newton's first law
- Newton's second law
- Newton's third law

WOW sheets

Explicitly noted	Also recommended
• Newton's first law • Newton's second law • Newton's third law	• What is force? • What is mass? • What is acceleration? • What is friction?

Additional equipment

- Timers

Delivery recommendations

The Why question

Before you begin the investigation, have students think about and answer the 'why' question. Offering everyone quiet independent thinking time to start is a good way to ensure all students have the chance to consider what they already know. You can then have students share with a partner, a group or the class if you like. If students start to raise questions, encourage them to capture them on a Wonder sheet.

Parts 1 and 2

These two parts are interconnected. Together, they demonstrate the two sides of Newton's first law of motion: a body at rest stays at rest and a body in motion stays in motion (unless acted on by an outside force). The running procedure for both is:

1. Create a set build from instructions

2. Read about a test they will perform using the build[2]
3. Write a prediction about what will happen in the test
4. Run the test[3]
5. Capture observations and questions

At the end of part two, the concept of inertia is formally introduced. Students then explain the concept in their own words using the triangle and fidget spinner as examples.

The fidget spinner is then used as a segue to introduce Newton's second law of motion. This activity does not require students to perform calculations using Newton's second law, only to apply the concept that a larger force will result in a greater acceleration. Students may also realise that the direction of the applied force (for example, pushing the spinner bar down and towards the left) determines the direction of the acceleration (in this example, clockwise). Likewise, they may observe that a larger force allows the spinner bar to spin for longer (because the initial force of the spin is greater and therefore it takes longer for the net forces of air resistance + friction to overcome the force of the spin, slowing the acceleration and eventually balancing it back to a velocity of zero).

Part 3

The final part of the investigation uses a new build to investigate Newton's third law of motion. The running procedure for this part is:

1. Create the set build from instructions
2. Tinker with the build, paying particular attention to what the flipper bar does when it hits the flat surface beneath it
3. Capture observations
4. Investigate Newton's third law

Students then explain Newton's third law using the fidget flipper as an example.

Once students have completed the final part of the investigation, the Whysheet asks them to reflect on their original answer to the 'why' question and prompts them to capture new questions brought on by what they've discovered in this investigation. They can then break down their builds back into the component parts.

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[2] Ideally, students should make their predictions before they run the test. You may want to run this section as a class, reading the test explanations together and getting students to write down their predictions to prevent them from jumping straight into the test.
[3] It may be easiest to have students work in pairs to manage the timer. Alternatively, you can set and run a timer for the class as a whole.

Additional notes

Build notes

There are three builds in this project, the triangle (built and used in part 1), the fidget spinner (built and used in part 2) and the fidget flipper (built and used in part 3). Each student kit has enough parts for all three builds to be used at the same time.

The triangle (from part 1)

- If a student sets the triangle on its rounded corner, the triangle will be unbalanced and will fall. Likewise, if students knock the desk or table, the triangle will move. Help students identify the outside forces at play in these situations and distinguish that they are separate from the triangle itself.

The fidget spinner (from part 2)

- The fidget spinner is designed with a long handle so that students can hold the spinner in place on their desk or table with one hand and flick the spinner with their other hand. If you observe students not doing this (for example, holding the handle in their hand or not holding the handle) take the opportunity to get them to observe ('What do you notice?') the effects these variations have on the spinner's motion.

The fidget flipper (from part 3)

- There needs to be enough space between the two bushings, the two sides of the 'pyramid' and the flipper beam for the flipper beam to work correctly. If students aren't able to get the beam to flip well, have them gently 'wiggle' the flipper beam left and right to loosen the top of the build slightly.
- If students flip the beam very hard, the 'bounce' back up might be too quick for them to see. Encourage them to try a softer flip. You can also ask them about what they did observe and what they notice about where the beam ended up, using these elements to help them work out what motion must have occurred.

Answer key

The sample answers provided are intended to offer guidance only. Student answers will vary depending on their experiences. Answers to the initial 'why' question and the predictions are not supplied as there is no 'right' answer for these – they are intended to capture student's initial understanding.

Question	Sample answer
Newton's first law (inertia) using the triangle and fidget spinner	Newton's first law says that an object at rest will stay at rest and an object in motion stays in motion unless something makes the object change. The triangle was

	at rest and stayed at rest because nothing enacted a force on it. The fidget spinner started to spin (motion) when I flicked it (outside force) and kept spinning (inertia) for a while, but then it slowed down and stopped because environmental forces (friction and air resistance) were acting on it.
Newton's second law using the fidget spinner	Newton's second law says that a = f/m. The mass of the fidget spinner is constant no matter the force used to spin the spinner bar. The more force used to spin the bar, the greater the acceleration. In other words, the harder I flick the bar, the faster the spinner bar goes.
Newton's third law using the fidget flipper	When I push the flipper bar down into the desk, the desk pushes back up on the flipper bar because for every action, there is an equal and opposite reaction (Newton's third law). The harder I push the flipper bar, the more force it has when it hits the desk and so the greater the reaction force of the desk on the flipper bar. The flipper bar has only a little mass and the desk has a lot. This difference in mass is why the two objects are affected differently by the force. The acceleration on the desk by the flipper bar isn't enough to move the desk. But the acceleration of the reaction force from the desk on the flipper is enough to move the flipper. This force (equal and opposite direction) pushes the flipper bar back up. That's why the flipper bar 'bounces' off the desk.

Outside resources

These resources can serve as great wrap-ups to this investigation and 'provocateurs' to get students thinking about new questions. As links can disappear over time, a description of the content is included so that you can find a replacement if needed. An example 'I wonder...' question is also provided.

1. **Newton's three laws of motion applied to a bicycle**
   https://www.youtube.com/watch?v=JGO_zDWmkvk&feature=youtu.be
    - **About the video:** This short, animated TED-ED video looks at how Newton's three laws of motion can all be seen working whenever anyone rides a bicycle.

- **I wonder** how much force it would take to pedal a 10,000-pound bicycle?

2. **Newton's three laws of motion in a trip to Mars** https://thekidshouldseethis.com/post/newtons-three-laws-of-motion-royal-observatory-greenwich

    - **About the video:** This animation created by London's Beakus studio for the Royal Observatory Greenwich tells the story of four fictional astronauts traveling to Mars, demonstrating how Newton's three laws of motion impact their movement on the journey. The ideas that gravity is relative and the fact that weight is different from mass are also introduced.

    - **I wonder** if a rubber ball would bounce higher on Mars than on Earth?

3. **Fidget spinners in space** https://thekidshouldseethis.com/post/a-fidget-spinner-in-space

    - **About the video:** This video was filmed on the International Space Station and captures astronauts spinning a fidget spinner (and sometimes themselves) in space. Allowing the fidget spinner to float reduces the bearing friction by permitting the rate of the central ring and outer spinner to equalize.

    - **I wonder** how much longer a fidget spinner can spin for in space compared to on Earth?

4. **Fidget spinner marble run** https://thekidshouldseethis.com/post/spinners-a-kaplamino-marble-run-with-ten-fidget-spinner-tricks

    - **About the video:** Watch a marble run (Rube Goldberg style chain reaction contraption) which uses fidget spinners, and Newton's laws of motion, to get to the end. Other 'invisible forces,' including magnetism and gravity, can also be seen in use in the design.

    - **I wonder** what would happen if we made a marble run with our Whybricks fidget spinners?