Classroom physics

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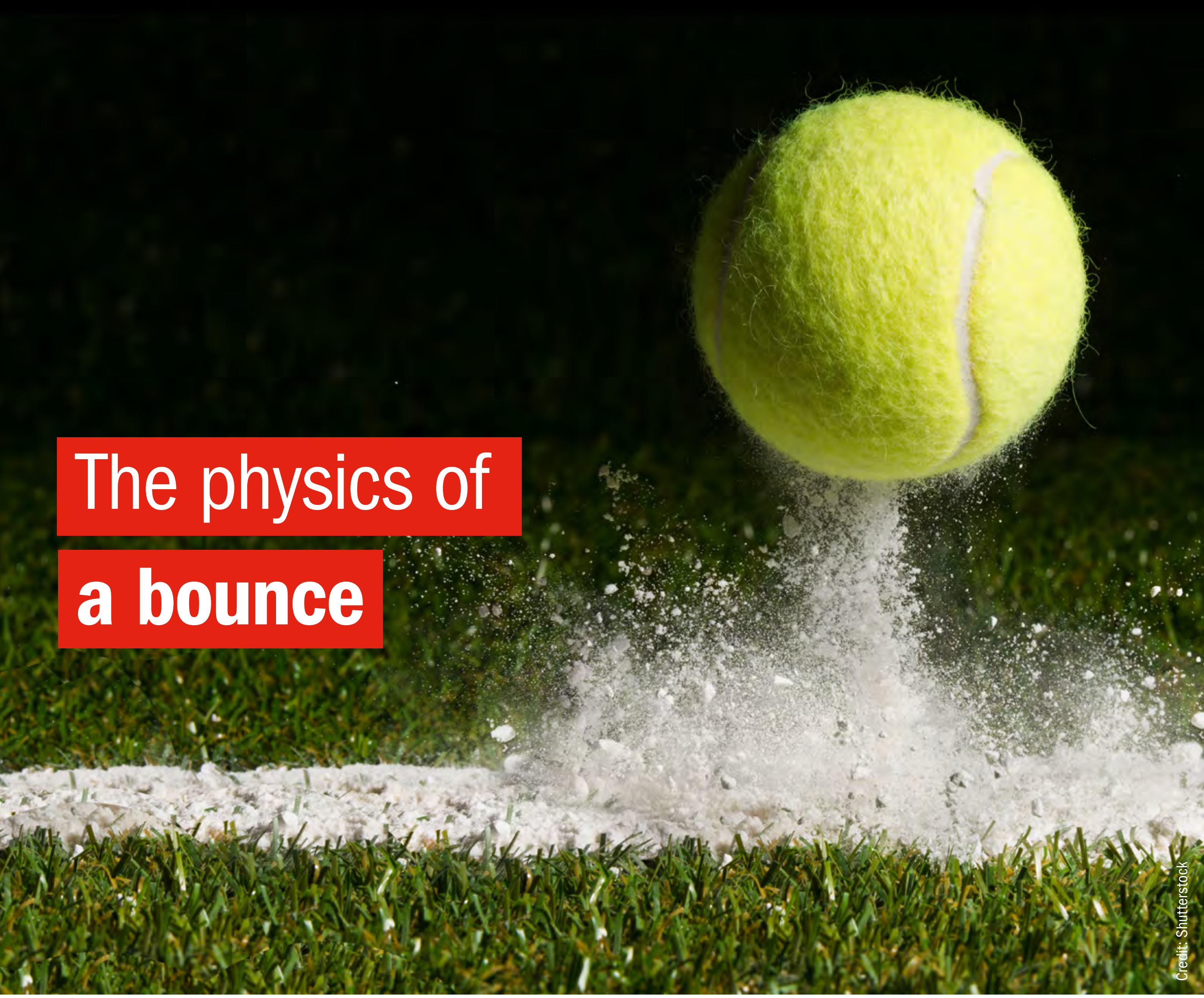

The physics of a bounce

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The state school with 100 sixth formers studying physics

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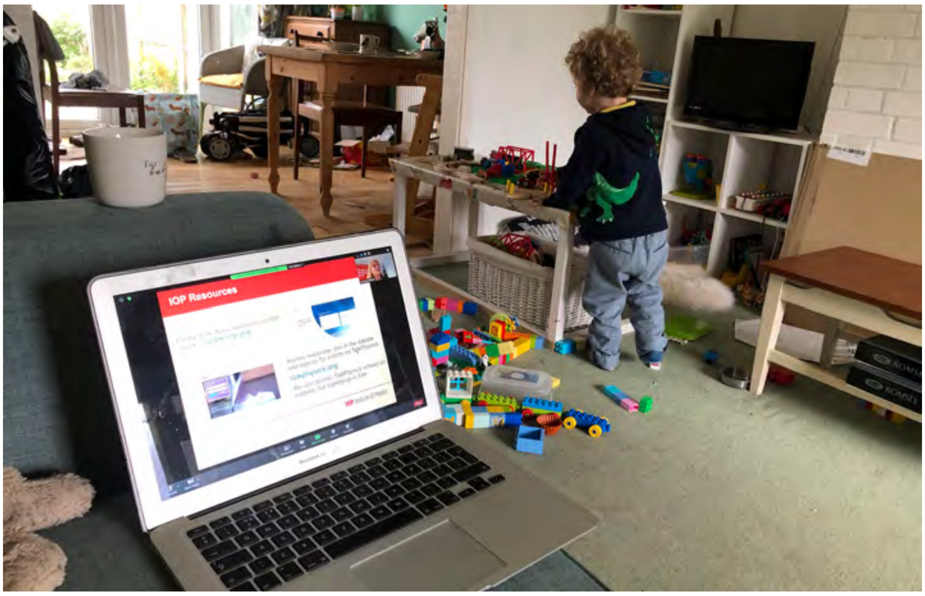

Credit: Elysia Allen

IOP teacher CPD has moved online and can be enjoyed from the comfort of your living room

This has been a year like no other. For those of us at the IOP who spend much of our lives working with teachers, COVID-19 brought an abrupt end to our face-to-face work in schools. To maintain our support we rapidly moved online but for most of us this was a step into the unknown: learning how to conduct CPD sessions with GoTo Meeting or Zoom, how to use multiple webcams plus visualisers and how to embrace novel technologies to make our sessions as engaging as possible.

During this challenging period, we've seen a particularly welcome effect of going online, with the number of teachers engaging with our CPD significantly increased. Since May we have reached more teachers and schools in the UK and Ireland than ever before. By delivering teacher support without the usual constraints of a physical location, we've been able to tailor our sessions for specific audiences such as newly qualified teachers or on specific topics such as maths in physics. There has been something for everyone.

Our glass has had to remain half full. We've learned and reflected, we've made some mistakes, but we've got a lot right. I've lost sleep over online sessions and spent days making a 30 minute video on vectors.

We are now looking to the future with our online IOP DOMAINS CPD programme. We've seen an opportunity to develop a suite of provision topic by topic, following the structure of our teacher resource website IOPSpark.

Of course, nothing can replace face-to-face sessions and we look forward to being able to offer them again. But online IOP CPD is here to stay and, over the coming weeks, months and years we will be working hard to support every teacher of physics across the IOP nations.

Mark Whalley
IOP education manager & coach

Find your CPD at
talkphysics.org/events

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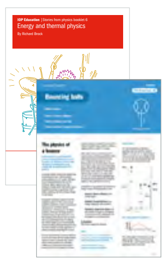
With this issue...

Stories from Physics: Energy and Thermal Physics.

Two extra copies of the physics pull-out to share with colleagues



Follow the IOP Education Department on Twitter @IOPTeaching

The state school with 100 A-level physics students

Henry Hammond - Alexandra Park School, London

Henry Hammond describes himself as a mediocre physics teacher who is always borrowing ideas from others. But since 2013, when he joined Alexandra Park School (APS) in north London, the number of students doing physics post-16 has jumped from 25 to over 100. So he must be doing something right.

The school was a specialist science and maths academy. It established the sixth form just 16 years ago, with an ambitious plan from senior leadership that has seen it grow to over 600 students this year. Henry was recruited to boost the numbers studying physics and he did just that. This has also meant boosting the teaching team from 1.5 to 7 members – the same staffing level as some of the most exclusive private schools.

"It all comes from leadership supporting us," he explains. "The head is very good at recruitment. Once he's recruited, you're the expert at the subject and teaching, and he believes you'll deliver the best lessons if you own them. It's very different from places where staff are lumped in with rules for students."

But there are more secrets to APS's success with post-16 physics. Firstly, the school is linked in to every form of physics teacher CPD and support available. Henry was an Ogden Trust teacher fellow and is now national secondary lead for the Trust, whilst the school is a partner school. It has run Teacher Subject Specialism Training courses for science teachers without a physics background and works closely with local IOP teaching coaches.

Students are not required to take maths alongside physics A-level and there is a physics-rich BTEC in applied science. The school's physics club is vertical, encouraging older students to work with younger ones and is designed to be fun rather than just a revision session. The STEAM club is for year 7 and has been led by physics teachers for the past six years.

In 2018, the school created a bursary access scheme, offering £500 to girls and those from disadvantaged backgrounds taking a physics or chemistry A-level. Henry says that the bursary isn't seen as a standalone project in the science department.

"Budgets are tight," he admits. "However widening access to education for underrepresented groups is important to us. Finances are managed prudently and used to actively meet our charitable objectives. Our collegiate way of working means departments across our school encourage each other and share ideas on how to improve uptake of their subjects. Offering the STEM bursary is one such opportunity."

Other initiatives have included free exchange visits as part of the Mandarin Excellence Programme in the languages department, fully-funded work experience placements in healthcare courses and subsidised instrumental tuition in the music department.

There is still some way to go. The proportion of female A-level physics students still hovers around the national average at just over 20%. Although more than a third of their physics students are from a BAME background, this is lower than the overall proportion in the sixth form. And when students move from studying four A-levels to three at the end of Year 12, there are still some who choose to drop physics in favour of one of their other subjects.

But Henry's dynamism and the team around him are a recipe for success, recognised by the IOP this year as a winner of an IOP Teachers of Physics Award. Henry remains modest: "I love physics and getting students to understand it. I have to work really hard to understand some bits though. Maybe that's what makes it work - students can see my brain working hard. Year 13 are now better at physics than me, I just have 15 years of examples."

more...

Read about all the IOP's 2020 award winners at **iop.org/awards2020**

Congratulations to the 2020 IOP Teachers of Physics Award winners

Catherine Dunn
Scottish Schools Education Research Centre and St Leonards School, St Andrews

Matthew Lewis
Hawarden High School, Hawarden

Estralita McCall
Brentwood Ursuline Convent High School, Brentwood

Jackie Flaherty
Chipping Campden School, Chipping Campden

Mark Logue
St. Mary's College, Derry

Ian Udall
Loreto Sixth Form College, Manchester

Limit Less:

it's time to stop limiting young people's futures because of who they are

The Institute of Physics has launched the Limit Less campaign to tackle one of the central challenges facing the physics community: its lack of diversity. Over the next few years, the IOP will campaign for systemic change.

We want to see more young people from groups that are under represented doing physics after the age of 16. But the campaign is not directly aimed at young people themselves. Instead, it is aimed at those who help shape their opinions and decisions.

A recent IOP report shows that, despite the ongoing work of physics teachers in schools and colleges, too many students are deterred from continuing with physics by people whose opinions they trust. Misconceptions about the nature of physics can form from an early age and dissuade students from choosing or considering physics. These misconceptions are shaped by a wide range of influences, including their parents and carers, teachers, communities, and messages in the media and on social media.

Young people are told "physics is too difficult", "it's not creative" or "it's boring". Sometimes, teachers also direct their students away from physics if they feel that they aren't "suited" to the subject.

The report also shows that young people are being steered away from physics because of prejudice and stereotypes. They are made to feel, implicitly or explicitly, that physics is not for the likes of them based on their ethnicity, their gender identity, their sexual orientation, their disability or their social background. This message can come from both outside and inside their schools.

Through the Limit Less campaign, we will help more young people to seize the opportunities physics offers. In particular, our report highlighted the four groups named below.

Young people in these groups are no less able to study physics than any other demographic group. The underrepresentation of these groups illustrates how society's biases and expectations can negatively affect their choices.

Our work shows that schools and teachers can significantly improve their opportunities and remove the limits on their choices by addressing those biases as a whole school. But this is not an issue teachers can solve alone.

The Limit Less campaign is lobbying government to provide greater support and empowerment for teachers to lead the way in supporting their students into physics. The campaign is also targeting the other key influences on young people, changing the way physics is represented not just in school but also at home, in the media and on social media.

People of **Black Caribbean descent** are least likely to pursue physics post-16 in England, with **only 0.5% progressing to A-Level** despite making up 1.4% of all young people aged 16 – 19 nationally

In England, **only 2.7% of students from the most deprived backgrounds choose physics** post-16 compared to 8.1% of the least deprived

In 2020, **physics was the second most popular A-level subject for boys** in England and Wales. For **girls,** physics came **15th and 16th** respectively

Only 13% of physics undergraduates in the UK had a known disability in records from 2017/8 - much lower than the 19% for all working age adults

Did anyone in your family or school discourage you from studying physics? Were you ever told physics wasn't for the likes of you? Here are some responses when we asked IOP members and students in the build-up to our Limit Less campaign.

> "This feeling of being seen as 'other' made it difficult for me to make friends so I didn't have anyone I could discuss the work with, or ask if we had homework, or partner up with for practicals."

Sole female student in an A-level class

> "My A-level physics class had 20-25 students but only four students weren't male, including me."

Non-binary undergraduate IOP

> "I was studying for my GCSEs when I suffered a traumatic injury to my legs. That and being from a low socio-economic group and an area with a high index of deprivation placed additional hurdles in my way. I managed to scrape my way into Lancaster University. By the end, I finished with a first class degree."

Male IOP member

> "I realised that I didn't know anyone working in a STEM field except my GP or my dentist. I didn't know anyone who looked like me … I was deeply discouraged by my physics teacher, who actively worked against me and other students of colour."

Undergraduate physics student

IOP Limit Less Campaign

iop.org/LimitLess

- download the report
- find out what we're doing
- join the campaign

Limit Less

IOP coach receives Birthday Honour

Credit: IOP

Helen at work, delivering a session to teachers at an IOP Stimulating Physics Summer School in 2013

Congratulations to Helen Pollard who has received an MBE in the 2020 Queen's Birthday Honours list for services to physics education.

Helen's career as a science teacher and coach spans five decades. She has worked for the IOP since 2006, first as a physics network coordinator and currently as a consultant and teacher-coach. She has also worked with the Gatsby Foundation and the Ogden Trust.

Speaking about her honour, Helen said: "I am delighted to receive this award on behalf of my close colleagues and the many teams of volunteers who have given their time and expertise to pass on the baton of enthusiasm for the subject. It is very rewarding to be around when students or teachers are thinking. Some of the best moments of my teaching career involve the apparently simple questions that people ask which make me rethink my own understanding."

Helen has been dedicated to the development and delivery of top-quality science education, and to supporting teachers through their careers to help them inspire young people. In her current role as a teacher-coach, she has worked closely with school science departments for long periods, providing significant support to teaching staff. In her early career, she also taught music.

Gary Williams, national coordinator for the IOP Teachers Network, said: "All of us who have worked with Helen are delighted that her expertise and humanity have been recognised with this award. She just is an amazing person. The way she interacts with people is on another level."

more...

iop.org/about/news/mbe-awarded-to-iops-helen-pollard

I want to re-inspire teachers' love of physics

Lisa Jardine-Wright is the IOP's new Vice President for Education. She has worked with teachers throughout her career and is director and co-founder of Isaac Physics, which offers free online support and resources to teachers and students.

Credit: IOP

Lisa received the IOP's Lawrence Bragg Medal in 2019 for jointly setting up and directing Isaac Physics

What are the challenges of teaching physics today?

League tables. Needing to teach to the exam. The societal expectation you either can or can't do maths or physics: it's not true! You need time to make mistakes and practise and, if you do, you get better - it is the same as for gymnastics, languages, music or football.

As a CPD specialist, what one thing can teachers do to improve their classroom?

Create an environment in which students see mistakes as a positive part of their learning experiences – an environment that rewards perseverance. A mistake isn't a negative thing, it's a learning opportunity.

How can the IOP further support teachers?

Enable teachers to be allocated time to re-inspire their love of physics and do subject specific CPD; enable them to take students out of the classroom; and increase collaboration between maths and physics departments.

What impact will the IOP's Limit Less campaign have on physics in schools?

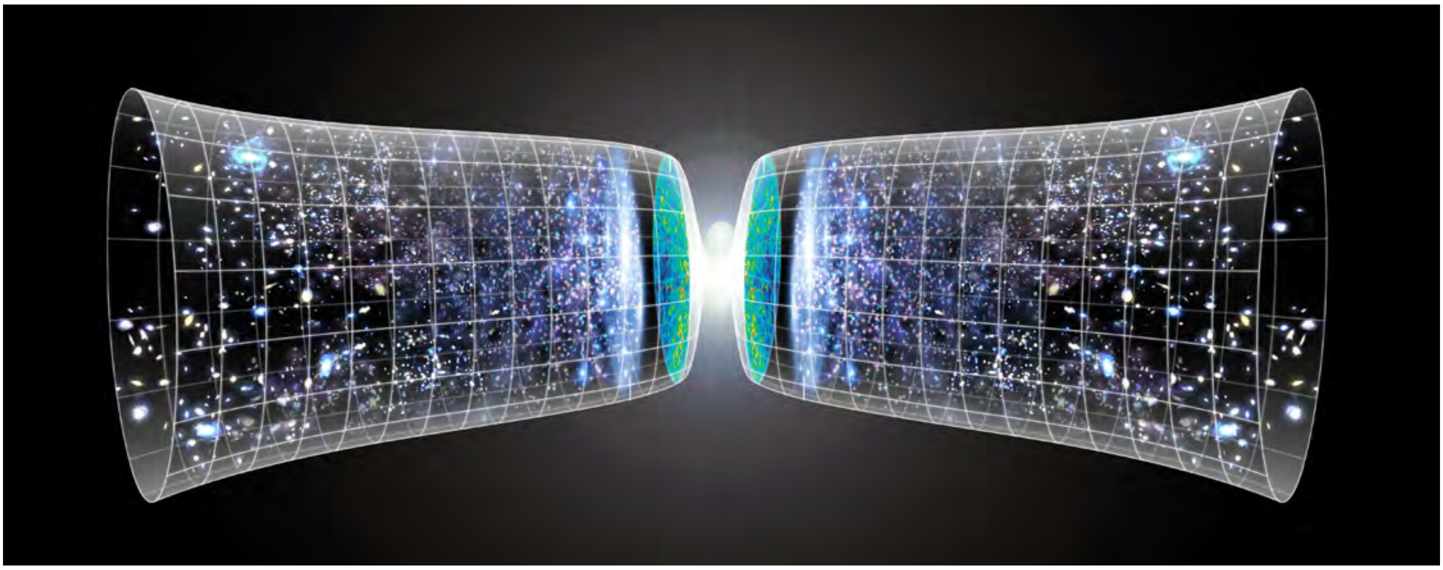
Physics needs a diverse community to solve current world problems. We all (families, teachers, friends) need to be aware that we can unintentionally introduce bias when trying to be supportive with comments like, "Don't worry, physics is really hard" or "I don't like maths either". From nursery and primary school all the way through education we must avoid imposing preconceptions or limiting what students can achieve.

What is your favourite demo?

The disappearing test tube: put an empty test tube in a beaker of olive oil, fill the test tube with olive oil and watch it disappear. It's super quick, the kit is easy to get, you can use it to explain refraction and you always get a "wow" from your audience.

more...

Find online IOP teacher CPD at **iop.org/domains**
Read up and join the Limit Less campaign at **iop.org/LimitLess**
Watch the disappearing test tube at **bit.ly/disappeartesttube**
Visit Isaac Physics at **isaacphysics.org**



Credit: Ben Tuckwell

From the Big Bounce viewpoint, the present universe may have developed from a predecessor (far left). At the end of its existence, this predecessor contracted to a tiny volume that then rebounded to create our cosmos (far right). This process could continue forever.

Big Bang theory's rival keeps bouncing back

Most students will have heard of the Big Bang and be able to say that it was the beginning of the Universe. Some might even tell you that it happened about 14 billion years ago. What they are unlikely to know is that Big Bang theory has some big problems.

Big Bang theory tells us that 13.8 billion years ago – before Earth, the Solar System, the Milky Way or even particles existed – the Universe spontaneously materialised from nowhere and nothing, and in less than a blink of any eye, inflated like a balloon. In the subsequent period of more sedate expansion, matter formed and mixed together, leaving a largely blank cosmic canvas with a few flaws here and there that went on to become the life-giving galaxies and stars we see today.

But in recent years, questions have grown louder about this view of the Universe's beginning, and indeed about our current understanding of how the cosmos works. Much of this doubt stems from differences between what theory predicts and what is observed. For example, there should be gravitational waves we can detect from quantum fluctuations during the very early Universe's rapid and brief inflation phase. They don't exist. Also, the relic radiation left over from the Big Bang that permeates all space, known as the Cosmic Microwave Background, should be roughly uniform. It's not. Most importantly from a theoretical perspective, at the moment of the Big Bang, everything is squeezed into a space with zero volume and infinite density, known as a singularity. If this happens, physics completely breaks down. These and many more anomalies and problems point to something missing from our cosmic understanding.

Though most researchers believe the faults in Big Bang theory will be ironed out in time, an alternative idea gaining traction is that the Universe did not originate in a Bang at all, but in a Bounce. In this scenario, the Universe expands up to a certain point, stops and then contracts back down to a tiny size, only to then start expanding again, over and over. If true, we could be living in the first or any one of an infinite number of Universes made by successive Bounces.

"Dark energy" plays a key role for some Big Bounce supporters. A mysterious property of the fabric of space itself, dark energy is thought to make up around 70% of the Universe. It is believed to power the Universe's accelerated expansion that we are witnessing right now. But in the far future, it could become less concentrated, leading to decelerating expansion, and the eventual contraction of the Universe – ready for the next Bounce and a fresh new Universe.

The Big Bounce has faced the same criticism as the Big Bang. At the point between contracting and expanding, the Universe forms a nonsensical singularity. Despite sharing this fundamental problem, Big Bang theory's success in many other regards saw Big Bounce ideas fade from view during the 1980s. However, recently two groups consisting of Paul Steinhardt and Anna Ijjas, and Neil Turok and Steffen Gielen have rekindled the Big Bounce. In very different ways, they have both demonstrated that it is possible the Universe would never actually become a singularity. What's more, Ijjas may soon identify unique features of a bouncing universe for astronomers to hunt down. If astronomers spot any of these telltale signs, the Big Bang's rival will have truly bounced back into contention to explain the origin of the Universe.

Dr Benjamin Skuse
Freelance science writer

more…

Student-friendly introduction to the Big Bang theory at **iop.org/big-bang**

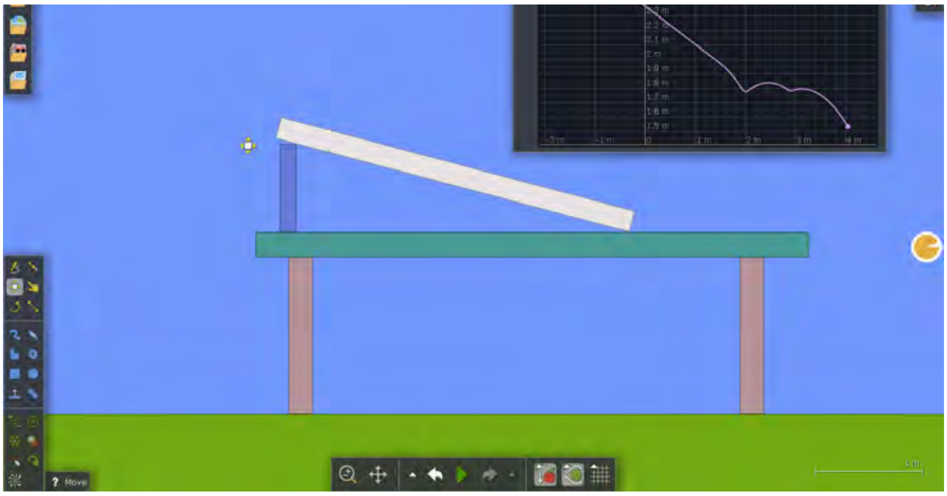
Latest Physics World article **bit.ly/PWbigbounce**

Physics education research

Using sandbox simulations to support learning physics

In this column,
James de Winter
(University of Uppsala and University of Cambridge)
and Richard Brock
(King's College London)
highlight accessible and usable resources based on research into physics education.

join the Physics Education Research (PER) group on Talk Physics at **talkphysics.org/groups/physics-education-research-per** or email **research@teachphysics.co.uk** to get involved with physics education research discussions.



Credit: Algodoo

Richard Brock's recreation of Euler and Gregorcic's experiment on the Algodoo sandbox

In our June 2020 column, we looked at research on the effectiveness of simulations in general for supporting student learning in physics. Here we discuss a particular form of simulation, the sandbox, which allows students to explore physical phenomena in an open-ended way.

Researchers have hypothesised that the concepts taught in physics are hard to acquire because they can differ from our experiences of the world, for example, students do not encounter friction-free surfaces or light inextensible strings! So-called microworld simulations, in which students can engage with simulated objects under controlled conditions, for example, in the absence of air resistance, have been proposed as a useful way to develop their intuitions.

One freely available physics sandbox simulation, Algodoo, allows students to create cartoon-like two-dimensional simulations of physical situations. The software allows, for example, the forces acting on objects to be visualised and graphs of various variables (including velocity and acceleration against time) to be plotted. It also allows students to change variables that are not easily controlled in classroom practicals, such as the coefficient of friction and the gravitational field strength.

Research into the use of sandbox simulations is at an early stage, but a paper by Elias Euler and Bor Gregorcic hints at the usefulness of such technology in the classroom. A challenge of learning physics is that it can be hard for students to draw links between their experiences with physical objects (such as pucks and ramps) and the abstract symbolic representations used by physicists (such as a velocity time graph of the motion of the puck). Euler and Gregorcic suggest that a digital learning environment can act as a bridge between the physical world and the formalisms of physics.

The researchers describe a study in which two students used Algodoo alongside some physical apparatus (a hockey puck sliding down a ramp on a table) and were videoed by the researchers. They were set the task of discovering the relationship between the height of the ramp and the horizontal distance the puck travels from the end of the ramp till it hits the floor.

They describe a discussion between the students, focused on a graph they had created in Algodoo displaying the x and y position of the puck. The ramp is set up such that there is a short stretch of table between its end and the edge of the table, and the students discuss whether the horizontal distance the puck travels should be measured from the end of the ramp or the edge of the table. The students use the virtual world, with its simulated model of the ramp and table, to determine the meaning of the point of zero-displacement on the graph. This negotiation of different forms of representation (the physical and symbolic) is reported to have occurred without formal instruction by a teacher about the nature of different representations.

Whilst the authors caution that their data arise from a single case study, they speculate that the 'messiness' of an open, sandbox simulation like Algodoo may encourage learners to explore their understanding in ways that don't occur in more structured traditional teaching environments.

more...

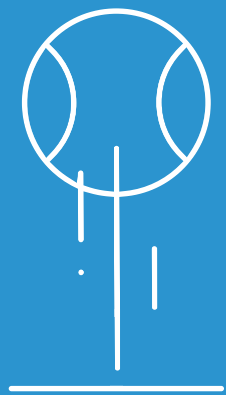
Read Euler & Gregorcis's paper at **bit.ly/CPsandbox**

Gregoric co-authored a more recent paper at **bit.ly/PEDalgodoo**

Download Algodoo at **algodoo.com**

Pull out and keep!

Bouncing balls



What's inside:

The physics of a bounce

A bouncing ball is a good illustration of why an energy analysis can be useful in physics. The challenge is how to avoid your students conflating the energy analysis with an explanation of what's going on.

An energy analysis provides the quickest way of predicting the way a ball bounces by putting limitations on the height it will reach. And it's not just physicists who use this technique. Sports regulators use this shortcut to identify which balls can be used for professional play by stipulating a ball's bounce efficiency, the ratio of bounce height to drop height.

Keeping the explanation separate from the analysis is important. Why a ball bounces should be described in terms of mechanisms and processes, the forces that act, accelerations, velocities and/or the elastic properties of the ball. An energy analysis should be based on two snapshots, one at the beginning of the process and one at the end. For a bouncing ball, start by keeping the analysis simple by only considering the amount of energy stored gravitationally when the ball is released and then again when it reaches maximum height after the bounce.

It is also worth making a conscious effort not to mirror the motion with the energy analysis. There is no need to consider every way in which energy is stored as the ball drops, collides and compresses, decompresses, launches itself, rises and stops. Use forces and mechanisms to explain the journey of the ball and focus the energy analysis on the two heights (before and after the bounce).

Slow motion videos can also be an aid. If students have slow motion capability on their phones they can see that the ball speeds up as it falls and slows down as it rises. Unfortunately, even the best phones do not have a high enough frame rate to show what happens in the few milliseconds the collision lasts but an online search of "slow motion ball bouncing" reveals lots of videos that you can use to show the ball going through compression and decompression during the impact to help make the link to forces.

In this pull-out, the activities are based on an energy analysis of the gravitational store:

- **Activity 1: Bounce efficiency** is for younger pupils
- **Activity 2: Stacked ball drop** is an energy analysis for older students.
- **Worksheet: Temperature Bounce** will take students through an investigation at home into how the 'bounciness' of a ball depends on its temperature.

Dr Taj Bhutta
IOP school engagement manager

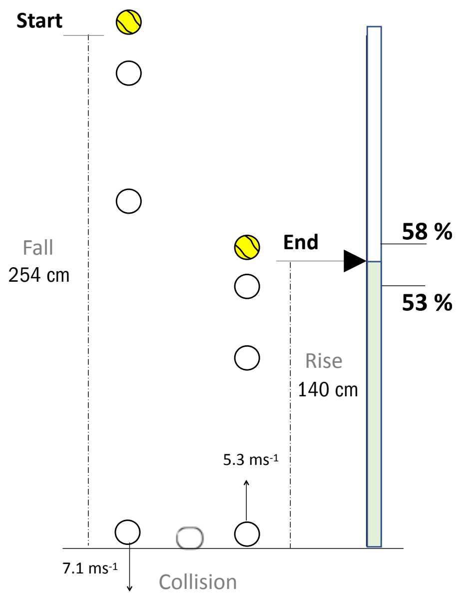
more...

Read our blogs on the new language for energy in the curriculum at **spark.iop.org/collections/energy-new-curriculum**

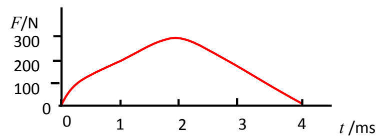
Teacher CPD videos on energy **spark.iop.org/energy-cpd-videos**

Tennis bounce

The International Tennis Federation stipulates that only balls that rebound between 135 and 151 cm when dropped onto a concrete floor from a height of 254 cm can be used for professional play (this is known as the 100-inch drop test).



Force-time graph for the collision



The collision lasts 4 milliseconds and the ground exerts a force F on the ball of up to 300 N. This is 500 times the size of the gravitational force on the ball.

Activity 1: Bounce efficiency

In this activity, students investigate the relationship between drop-height and rebound-height for a ball. You can use it to introduce the idea of efficiency.

Equipment

Each student will need:

- Metre rule
- Tennis or other sports ball
- Hard floor
- Clamp stands to hold metre rule (optional)
- Mobile phone that can record in slow motion (optional)

Procedure

Ask students to:

1. Drop the ball onto a hard floor from a height of 1 m.
2. Devise a method for determining the height that the ball bounces up to (by eye or using slow motion video).
3. Take repeat measurements to find an average bounce-height for a 1 m drop.
4. Repeat for at least two other drop-heights.
5. Plot a graph of drop-height against (average) bounce-height.
6. Draw a best-fit straight line through your results and use the graph to predict the bounce-height from an unknown drop height (eg 2 m).

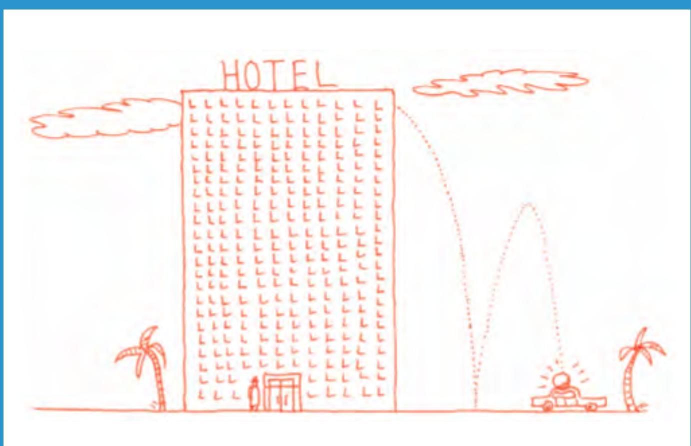
Teaching notes

Students should find that bounce-height and drop-height are linearly related. Their gradient will depend on the ball and surface used, but will always be less than 1. They can calculate an average value for the bounce efficiency as a percentage by multiplying the gradient of their graph by 100%.

Emphasise that energy considerations do not explain why a process happens. The force of the ground on the ball is why it bounces. The ball deforms when it impacts the floor and as the compressed ball springs back into shape it pushes on the ground and the ground pushes back. Different balls spring back by different amounts and the more squashed they become during the collision (ie higher impact speed), the greater the height they bounce back to.

Extension

As a follow-up activity, students can investigate how bounce efficiency changes after putting the ball in the freezer. Instructions for your students to try this activity at home are on page 12.



Stories from physics: super balls

Super balls are a well-known toy made from an elastic polymer ... they bounce back from a surface with 90% of their initial velocity. Wham-O, the manufacturers of the original super ball, produced a giant version of the toy as a promotional stunt. The ball was accidentally dropped from a room on the 23rd floor of a hotel in Australia. It is said to have bounced back up to the 15th floor on its first bounce and then struck a parked car, causing considerable damage.

spark.iop.org/stories-physics

Activity 2: Stacked ball drop

In this activity, students explore how high a ping pong ball bounces when dropped by itself and then with a golf ball. You can use it to show how an energy analysis allows us to put limits on possible outcomes.

Equipment

Each student will need:

- 30 cm ruler
- Golf ball
- Ping pong ball
- Bench/table to bounce off
- Sticky tape
- A4 sheet of clear plastic (eg document wallet)
- Mobile phone that can record in slow motion (optional)
- Mass balance if available (capable of measuring to nearest g or better)

Procedure

Ask students to:

1. Roll the clear plastic A4 sheet into a 30 cm long tube with a diameter slightly wider than the golf ball.

2. Use sticky tape to hold the tube in shape and stand it upright on a bench or table. Ask an assistant to gently grip the bottom of the tube (or use a clamp stand at the top to keep it upright).

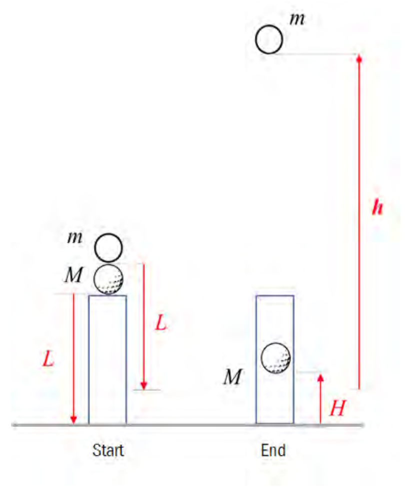
3. Hold the ping pong ball so that the bottom of the ball is at the top of the tube. Let go. Measure the height the ping pong ball drops and then bounces to. Calculate the bounce efficiency.

4. Repeat for the golf ball.

5. Hold the ping pong ball directly above the golf ball and drop the two together so that the ping pong ball bounces straight up out of the tube. This may take a few goes.

6. Measure the height the golf ball reaches after the two-ball collision. Assume the bounce efficiencies are 100% and try to calculate the height the ping pong ball will reach.

Teaching notes



The start and end points of the energy analysis are illustrated above.

The length of the tube is L and, for the ping pong ball and golf ball respectively, the rebound heights are H and h and masses are M and m. For a perfectly elastic collision, we can say that the energy stored gravitationally before the drop would be the same as the energy stored gravitationally afterwards. Therefore:

$$(M + m)gL = mgh + MgH$$

And so the height of the ping pong ball can be predicted using:

$$h = \frac{M}{m}(L - H) + L$$

This will be a maximum possible value for h and we have assumed a 100% bounce efficiency. The energy analysis shows that the bounce height of the ping pong ball can be higher than its starting height, but, as ever, it is worth emphasising that the analysis does not explain why the ball leaves the tube, it simply confirms that it is possible.

Although a detailed explanation of the mechanisms involved is beyond school level physics, discussing relative speeds will help your students appreciate why the ping pong ball flies out of the tube. In a two-ball drop, there are two collisions in quick succession. The golf ball collides with the bench and then, travelling upwards, it collides with the downward travelling ping pong ball. The speed at which the ping pong ball approaches the surface it is bouncing off (ie the golf ball) is higher in a two-ball collision than if it was heading towards the stationary bench.

more...

For a technical and detailed discussion see: *The two-ball bounce problem* by Berdeni et al
doi.org/10.1098/rspa.2015.0286

Temperature bounce

In this activity you will investigate whether a ball will bounce more or less after a night in the freezer.

How long this activity takes

2 x 20 minutes with 5+ hours in between for putting the balls in the freezer.

What you need

- Flat hard floor next to a wall
- Tape measure or ruler to measure height
- Blu tack to mark positions on wall
- One or more balls (eg tennis, ping pong)
- Enough space in a freezer to contain ball/s
- Plastic bag to store balls in freezer
- Pencil and paper to record results

What to do

1. Watch the video at **bit.ly/TempBounce.**
2. Mark a point 1 metre from the ground on a wall.
3. Hold a ball so its lowest point is at the 1 metre point.
4. Drop the ball and mark where the lowest part of the ball is after the first bounce. When looking at the bounce-height, keep your head in the same place to avoid problems with parallax.
5. Repeat to obtain a total of six readings.
6. Work out the average of the six readings and their range (eg if the range of the readings is 3 cm, write it as +/- 1.5 cm).
7. Repeat using as many balls as you wish (and have space to store in your freezer).
8. Put the tested balls into a plastic bag and store them in the freezer overnight.
9. The next day, remove the balls one at a time from the freezer and repeat the bounce tests. Make sure you test each one immediately, so it doesn't have time to warm up. Again, record the average and the range.
10. Draw a results table like the one below and add your values.

	Before overnight in freezer		After overnight in freezer	
Ball type	Average first bounce height (cm)	Range of first bounce height (+/- cm)	Average first bounce height (cm)	Range of first bounce height (+/- cm)

11. Enter your results on the NPL webpage at **bit.ly/NPLbounce**

NPL

Something else to try - For other measurement challenges to try at home, visit the National Physical Laboratory website **npl.co.uk/measurement-at-home**

Moonbounce

In 1940, an engineer at the British Post Office proposed the idea of using reflections from the Moon, so-called Moonbounce, in radio communication. Subsequently, anecdotal reports emerged from radio operators that it was indeed possible to send signals in this way. The first documented lunar reflection came in 1946 from the US Signal Corps as part of Project Diana. The experimental setup had an interesting quirk because the capacitors available at the time were too leaky to retain charge over an extended period. In order to amplify the detected signal, the voltage pulse received was used to hydrolyse water and the volume of resultant gas measured to analyse the reflection. Project Diana led to the establishment of a Moonbounce link between the naval base at Pearl Harbour and the naval headquarters in Washington DC.

The bouncing wedding ring

You are likely to have heard Charlie Duke's voice, speaking as Mission Control to the first astronauts on the Moon. After a nervous landing, Duke radioed: "Roger, Twank... Tranquillity, we copy you on the ground. You got a bunch of guys about to turn blue. We're breathing again. Thanks a lot!" Duke travelled into space himself on Apollo 16. On the second day of the mission, the pilot of the command module, Ken Mattingly, lost his wedding ring and the crew searched for the precious object but couldn't find it. A week later during a spacewalk, Duke saw the ring fly past Mattingly, heading into space. He tried to catch it but missed. As Duke called out, Mattingly turned his head and the ring bounced off his helmet back towards Duke who caught it.

Meteoric bounce

The first reliably documented extra-terrestrial object to injure a human is the Sylacauga meteorite, a piece of rock the size of a grapefruit. In 1954, the 5.5 kg meteorite broke through the roof of a farmhouse in Alabama, bounced off a large wooden radio and struck Anne Hodges, who was napping on a nearby sofa. Hodges was badly bruised but otherwise unhurt by the collision.

Bouncy fruit

Cranberries are sometimes called 'bounceberries' because their ripeness is measured through their bounciness. The berries are forced to bounce over 10-18 cm high barriers and those that can't bounce over these walls are deemed too soft and unsuitable for sale. Researchers have dropped peaches from small heights (0.5 and 1 cm) to determine their ripeness, plotting force vs. time graphs. The firmest peaches had coefficients of restitution approaching 0.60 (meaning they would bounce back at over half the speed they hit the ground at); the ripest peaches had a coefficient of restitution of only 0.32.

more...

These stories were collected by Richard Brock, lecturer at King's College London and former physics teacher. Follow him on Twitter **@RBrockPhysics**

Download more Marvin and Milo activities at iop.org/marvinandmilo

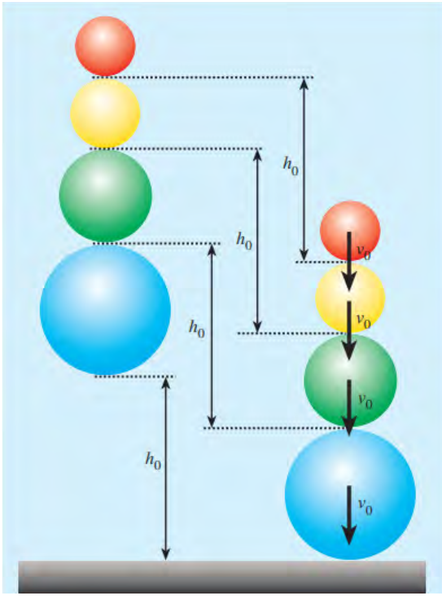
Physics*education*

Physics Education is our international online journal for everyone involved with the teaching of physics in schools and colleges.

Physics Education editor Gary Williams highlights his favourite papers on **bouncing** from the archive (this page) and picks his top articles from the current volume (opposite page).

Access over 50 years of articles at **iopscience.org/physed**

Affiliated schools have free access – email **affiliation@iop.org** for a reminder of your log in details.



Credit: Physics Education

The diagram shows an astroblaster as it falls and nomenclature used to analyse the situation

The Astroblaster

Bouncing papers abound in the pages of *Physics Education* but one paper that has to be included describes the physics of the classic demonstration beloved of teachers – the Astroblaster!

In this 2009 paper, *Astroblaster—a fascinating multi-ball collision* the author provides a detailed model of how the toy works. What makes it even better is that the empirical results don't match the model! So now you have a great excuse to buy one and try and get your students to create a better model while the little rubber ball from the top flies around the room.

more...
bit.ly/PEDastrob

Bouncing bombs

Physics and the Dambusters from 1989 gives the history and physics behind the Dambusters bouncing bomb exploits including a number of exercises (with answers) that students can be given.

bit.ly/PEDdambusters

Bringing this more up to date and getting more hands-on is the 2007 paper *Bouncing steel balls on water* by Michael de Podesta from the National Physical Laboratory where they recreated the Dambusters raid by building a pool and making ball bearings skip over the surface of the water. You can find slow motion video footage of the reconstruction on YouTube at

bit.ly/YTbounce

Credit: Physics Education

The ship tank as finally constructed. Notice the poppies in remembrance of those who died in the original action.

Force, acceleration and velocity during trampoline jumps

If your school has access to trampolines, or students have safe trampolines at home, then this 2017 paper with its "challenging assignment" will give you an excellent background when asking students to think about the physics of a bounce. Even without access to trampolines the thought experiment is a useful one, offering suggestions for useful scaffolding exercises and assessment questions.

more...
bit.ly/PEDtramp

Content representations to support out-of-field physics teachers

Content representations are a sort of planning or consolidation tool that allow you to get a good overview of your situation when you feel the need to reflect on or develop your teaching knowledge. In essence, it is a large table with columns that represent specific concepts you want to teach, with the elements of the column being filled with teaching methods, assessment tools and student difficulties associated with the concept. Simple to implement, this paper gives an insight into how to use this tool. Additionally, you could get the original book by Loughran, Berry and Mulhall, Understanding and Developing Science Teachers' Pedagogical Content Knowledge (2006 Rotterdam: Sense Publishers).

more...
bit.ly/PEDcontent

Remotely teaching Arduino by means of an online simulator

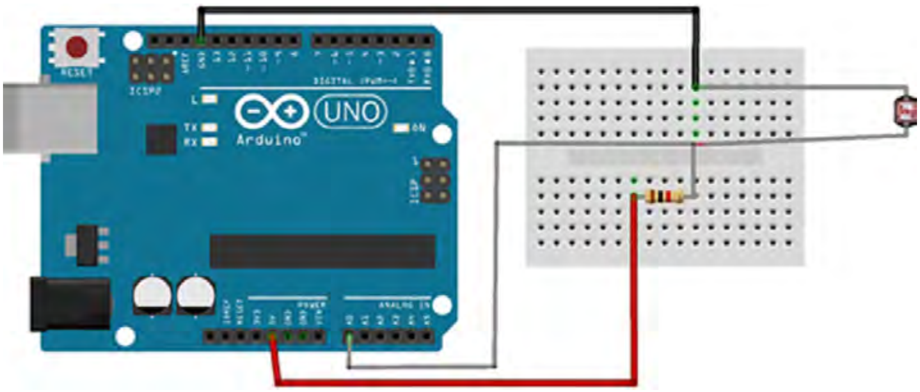
The Arduino is an interface that allows you to programme a sense and control board relatively easily. Over recent years, the pages of *Physics Education* have been full of papers that describe how Arduinos can be used in physics teaching. They can be bought very cheaply and could be an ideal device to send older students home with to do experiments – make sure students have understood how to use the board before they take it away and put it on a shelf to gather dust. This paper will help students use an online version of the device for free before you let them loose on the real thing.

more...
bit.ly/PEDarduino

Novel infrasound monitor project: real geophysics research on a budget

There is an increasing realisation that students should get a genuine experience of what physics is really about. So rather than rote learning, they should engage in experiments where no-one knows the outcomes and their progress should be scaffolded to allow them to design experiments for themselves (the Investigative Science Learning Environment project offers some good ideas for how to approach this - see **islephysics.net**). In this particular paper, the authors describe real physics experiments with kit they made themselves to detect long wavelength sound waves. It's a very interesting idea that most schools could implement.

more...
bit.ly/PEDgeophys



An Arduino LDR circuit

Credit: Physics Education

More recent articles

Optical coronae and iridescence: some simple hands-on activities
bit.ly/PEDcoronae

Water jet from a bottle in free fall
bit.ly/PEDfreefall

Space weather interference in Earth communications and construction of a small-scale radio telescope for Sun observation in radio waves using Arduino

bit.ly/PEDspaceweather

Electric eel electricity
bit.ly/PEDelectriceel

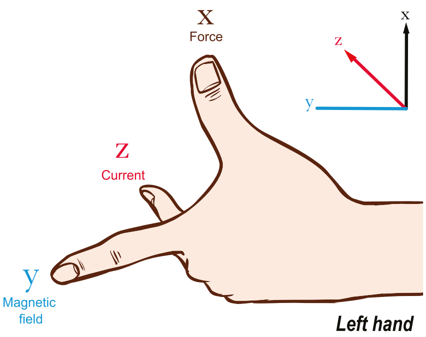
Using an Arduino in physics teaching: LDR as a simple light sensor
bit.ly/PEDardLDR

talkphysics

Dave Cotton, editor of our online discussion forum, chooses his favourite recent TalkPhysics discussion threads.

Log in or register to join the conversation at **talkphysics.org**

Credit: Shutterstock



Fleming's left hand rule

There is a great video, made for trainee teachers at Exeter University during the summer, on a simple method for students to answer Fleming's left hand rule problems using lolly sticks. Its creator Jill Noakes shared it at **bit.ly/TPfleming**

There is an older discussion where teachers discuss ways to tackle this "love-to-hate" topic at **bit.ly/TPfleming2**

Make your own Westminster power supply

In Jill's video, a Westminster power supply is used to provide the necessary current for magnetic demonstrations at low voltage. IOP coach David Farley uploaded plans to make a version including a parts list. This portable supply gives you a battery-based reliable power source with a current of around 7.5A **bit.ly/TPwestminster**

Electricity and French men

There are some great tips for helping students learn symbols and units for electricity. Elysia tells stories about Mr Coulomb, Mr Ampere, Mr Ohm and Mr Volta, whilst Nancy uses pictures of the people SI units were named after around her classroom wall as a talking point. Richard Brock, the author of Stories from Physics, offers a couple of Fleming stories in this thread about physicists and learning units. **bit.ly/TPfrenchmen**

More of Richard's stories can be found at **spark.iop.org/stories-physics**

Resources & discussion from 'A Day for Everyone Teaching Physics'

You can pick up resources and tips from CPD days even if you are unable to attend. There is a cornucopia of ideas from a recent day in the north east region at **bit.ly/TPyane20**

physicsworld

Stories from our magazine for the global physics community. Visit **physicsworld.com**

Credit: Shutterstock

Optical microscopy – how small can it go?

Scientists in the 21st century are armed with a multitude of imaging techniques, employing everything from atomic forces to sound waves in order to build up a view of the invisible world around us. But they're not done yet. Anna Demming takes a look at how methods of optical microscopy – imaging with visible light – have evolved from 17th century to the present day. These methods allow fragile samples to be studied without the need to expose them to the extreme conditions needed by other techniques, but were faced early on with a fundamental resolution limit caused by the diffraction of light. That limit wasn't broken until 1972, and researchers are now not only working out how to reduce the scale of the image itself, but trying to shrink the device onto a portable, smartphone compatible chip.

Find out how in the full article at
bit.ly/PWmicro

100 seconds to midnight

What are the moral implications of research? How can global catastrophes be judged? And whose responsibility is it to decide? For Eugene Rabinowitch and Hyman Goldsmith, two physicists who worked on the Manhattan Project, the science community have a duty to consider the impact of their work on humanity. Rabinowitch therefore set the 'Doomsday Clock' each year in the Bulletin of the Atomic Scientists by considering the global political situations and our proximity to humanity-ending disaster. The position of the clock is now set by a science and security board, which includes politicians and leaders in international relations alongside physicists, in consultation with the Bulletin's board of sponsors. In January 2020 they set the clock to 100 seconds to midnight, the closest it has been in its 73 year history – and all before the full scale of COVID-19 was known.

more...

Read why in the full article at
bit.ly/PWdoomsday

eic

EIC is the Royal Society of Chemistry's magazine for teachers. Visit **edu.rsc.org/eic**

Credit: Shutterstock

Socially distanced teaching and learning

Strategies and tools for classroom teaching from two metres away

Enable students to work independently

To reduce the degree of support students need during tasks, increase the difficulty incrementally, with practice between tasks to secure their knowledge. You can ensure students can work independently by modelling problems first and creating or adapting resources. I have found that just showing students a video before they start a task can help them follow instructions better.

Easy ways to check understanding

Collecting responses from as many students as possible is important to identify students who have misconceptions. Hand signals are one way of doing this: thumbs up/down for true/false or certain number of fingers for multiple-choice answers. Mini-whiteboards are excellent too, but remember they need to stay within the bubble, be quarantined or sanitised.

Technology allows us to see students complete their work in real time but at a distance. Students can work on a shared electronic document using Word or Google Docs, for example. Padlet, Nearpod and Classkick also allow the live collection of work.

Approaches to hands-free assessment

Developing an environment of honesty and self-assessment is important. Give students time to complete tasks and provide them with the answers to self-assess at strategic points. This will allow those who have not succeeded with the initial questions to seek support.

Marking books is another tricky proposition. Self-marking quizzes have become an important feature of my teaching since lockdown. They are a useful homework as I can see how students have done and adapt the next lesson accordingly.

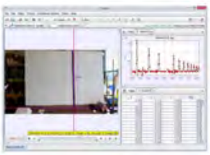
Helen Rogerson,
science teacher at Westonbirt School

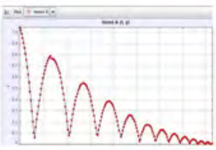
more...

Read the full article at **rsc.li/3IEsihP** and others on lockdown teaching on the *Education in Chemistry* website.

CLEAPSS

CLEAPSS is an advisory service supporting science and technology in schools. Its advice and guidance is recognised by Ofsted and the HSE for safe practice for practical work in schools. Visit **cleapss.org.uk**





Using tracker software for motion analysis

We have a leaflet packed with suggestions for using computer, phone and tablet applications to support practical work. There exists hundreds, if not thousands, of such apps across various platforms, but we have picked out a few which are currently used by some teachers to great success

This is just one of the ideas, where Tracker software was used to follow a bouncing ball. The same software could also be used in biology investigations, for example following the path of a woodlouse in a tray, although they are considerably less bouncy.

Tracker is freeware software which analyses motion from a video clip, produces a range of graphs from it, and can then calculate various quantities based on the motion. It is immensely useful in the science classroom, both in teacher demonstrations and student practical investigations. A short (20 seconds or so) video clip of an experiment needs to be recorded. It is important that the camera is stationary – perhaps fixed to a tripod – and whatever is being recorded is well illuminated with a colour which contrasts with the background.

Tracker could be used for class-wide activities, or perhaps as a differentiation tool for certain groups. A little bit of time invested in perusing the basics with your class can have profound effects when they engage positively with the software.

The below screenshots are for a simple experiment where the exponential decay of the maximum height reached for consecutive bounces can be seen on the graph on the left.

more...

Download tracker at **physlets.org/tracker**

Teaching & learning resources for remote/blended study iop.org/covid-19

Resources by physics topic

1. Earth and Space
2. Electricity and Magnetism
3. Energy and Thermal Physics
4. Forces and Motion
5. Light, Sound and Waves
6. Properties of Matter
7. Quantum and Nuclear Physics

Resources by age range

- 11 – 14 year olds
- 14 – 16 year olds
- 16 – 19 year olds

Resources by type

1. Videos to watch at home
2. Home experiments
3. Questions to check understanding and identify misconceptions

Calling trainee science teachers!

This year is particularly challenging for student teachers so we want to do what we can to support them as part of the IOP community. We'll share events, CPD, support opportunities and our resources.

Please direct trainee teachers to register at: **iop.org/student-teacher.**

There is an extra incentive for physics trainees!

QUBIT

Do you have students age 16-19?

Qubit is our e-newsletter for school and college students studying physics. Subscribers can read about:

- what's new in physics
- exam and university guidance
- information about physics careers
- upcoming events and competitions.

Students can sign up at **iop.org/qubit**

Help Santa save the North Pole!

Watch our festive video then channel your students' inner inventor with our STEM modelling challenge, perfect for a class activity or at home.

Starting with a box, we challenge you to get creative and have fun. Build a sustainable junk model and consider adding a coding element to get the model moving and talking. No idea is off limits.

Why not take a look at our challenge page for inspiration? We can't wait to see your amazing ideas! Make sure to share them with us on social media **#SaveTheNorthPole #SantaLovesSTEM @IETeducation**

Find out more: **theiet.org/santa**

The Institution of Engineering and Technology

CHARTERHOUSE

PHYSICS
SUBJECT BOOSTER COURSES
2021

Free **Saturday courses**
aimed at enhancing Physics subject knowledge

These successful courses have been running for 14 years.
The aim of the sessions is to provide insight and understanding of Physics.
The course will be held via zoom.
All courses run 11.15am-12.45pm.

Date	Course
Saturday 16 January	Electricity basics
Saturday 23 January	Electricity and Magnetism
Saturday 6 February	Waves and Sound
Saturday 27 February	Light
Saturday 6 March	Nucleus, Radiation
Saturday 20 March	Using demonstration to build understanding

There is no charge for materials or course tuition.

For more information on these sessions, please email Steve Hearn:
sth@charterhouse.org.uk

To register for a place and administrative matters, please email Lise Schreuder:
science@charterhouse.org.uk

CHARTERHOUSE SCIENCE DEPARTMENT
Telephone: +44 (0)1483 291698 email: science@charterhouse.org.uk

Registered Charity 312054

THE ROYAL SOCIETY
royalsociety.org/teachers

Why science is for me – new free resource

This new tool is for physics teachers and career leads to help students, and their parents, understand why science is a core subject. Aimed at students aged 14 to 16, the animation explores the key transferable skills gained from studying science, useful in a broad range of careers.

Access the animation and downloadable posters at
royalsociety.org/why-science

Royal Society's Partnership Grants

Through this scheme, your school could receive up to £3,000 to run an investigative STEM project in partnership with a STEM professional.
The 2021 round will open in February and specific guidance will be available for schools applying for a grant to support students with special educational needs and disabilities.

Visit **royalsociety.org/partnership** or email
education@royalsociety.org

THE ROYAL SOCIETY

Measurement at Home from NPL

Our lockdown-friendly physics challenges use equipment available at home. Although some - such as measuring the speed of sound and the one-second pendulum - are inspired by GCSE and A-level required practicals, they are pitched at a level accessible to all. Each challenge comprises: instructions (in written and video formats), a worksheet and a form to log participants' results which are used in a report of findings. Challenges introduce good measurement practices and real-world applications.

Please visit the resources and encourage student participation at **npl.co.uk/mah**

Contact NPL to suggest future topics or experiments by emailing **outreach@npl.co.uk**

NPL

DOMAINS CPD programme - through the curriculum through the year

Term 2020/21	Topic
Autumn 1 (late Sept)	Forces
Autumn 2 (early Nov)	Energy and Thermal Physics
Spring 1 (early Jan)	Electricity and Magnetism
Spring 2 (late Feb)	Light, Sound and Waves
Summer 1 (mid Apr)	Matter and Nuclear Physics
Summer 2 (early June)	Earth in Space

Each term, we concentrate on a different topic, supplying you with videos followed up with online workshops. Sessions are tailored to your level of teaching experience:

- Early career, newly qualified and trainee
- Experienced
- Coaches and CPD supporters.

We list the sessions regionally to help you get to know your local IOP coaches and meet other teachers in your area. But you are welcome to register for any online sessions that take your fancy.

"I found the pre-course videos really helpful."
Raji, trainee teacher

"It's good to see how other teachers work and a great opportunity to learn new things."

Ema, returning teacher

Coming up in spring term...

Electricity

This subject can be tricky to teach and so we'll work on developing subject and pedagogical knowledge. We'll cover core issues such as student misconceptions, effective use of models (including the rope model), practical challenges and calculations.

Light, Sound and Waves

Building on from Energy in the autumn term, we'll focus on this energy transfer pathway. We'll cover practical aspects of teaching waves, through to performing calculations and understanding the electromagnetic spectrum.

Browse and book at
talkphysics.org/domains-events

Watch CPD videos from all topics at
iop.org/domains

Other IOP CPD events

There are lots of other (online) CPD events going on, such as local events, regional days and other support programmes like our new "Maths on Monday" for anyone wanting to develop their understanding of the maths concepts required in teaching GCSE-level physics.

Browse and book at
talkphysics.org/events

Contact your IOP regional education manager to find out about teacher support in your area:

Scotland
Stuart Farmer
education-scotland@iop.org

Ireland
Lucy Kinghan
education-ireland@iop.org

Wales
Cerian Angharad
education-wales@iop.org

England

Yorkshire and north east
Jenny Search
education-yane@iop.org

North west
Graham Perrin
education-northwest@iop.org

Midlands
Ian Horsewell
education-midlands@iop.org

London, East Anglia and Kent
Jessica Rowson
education-leak@iop.org

South
Trevor Plant
education-south@iop.org

For support running CPD, contact our Professional Practice Group

education-ppg@iop.org

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