Classroom physics

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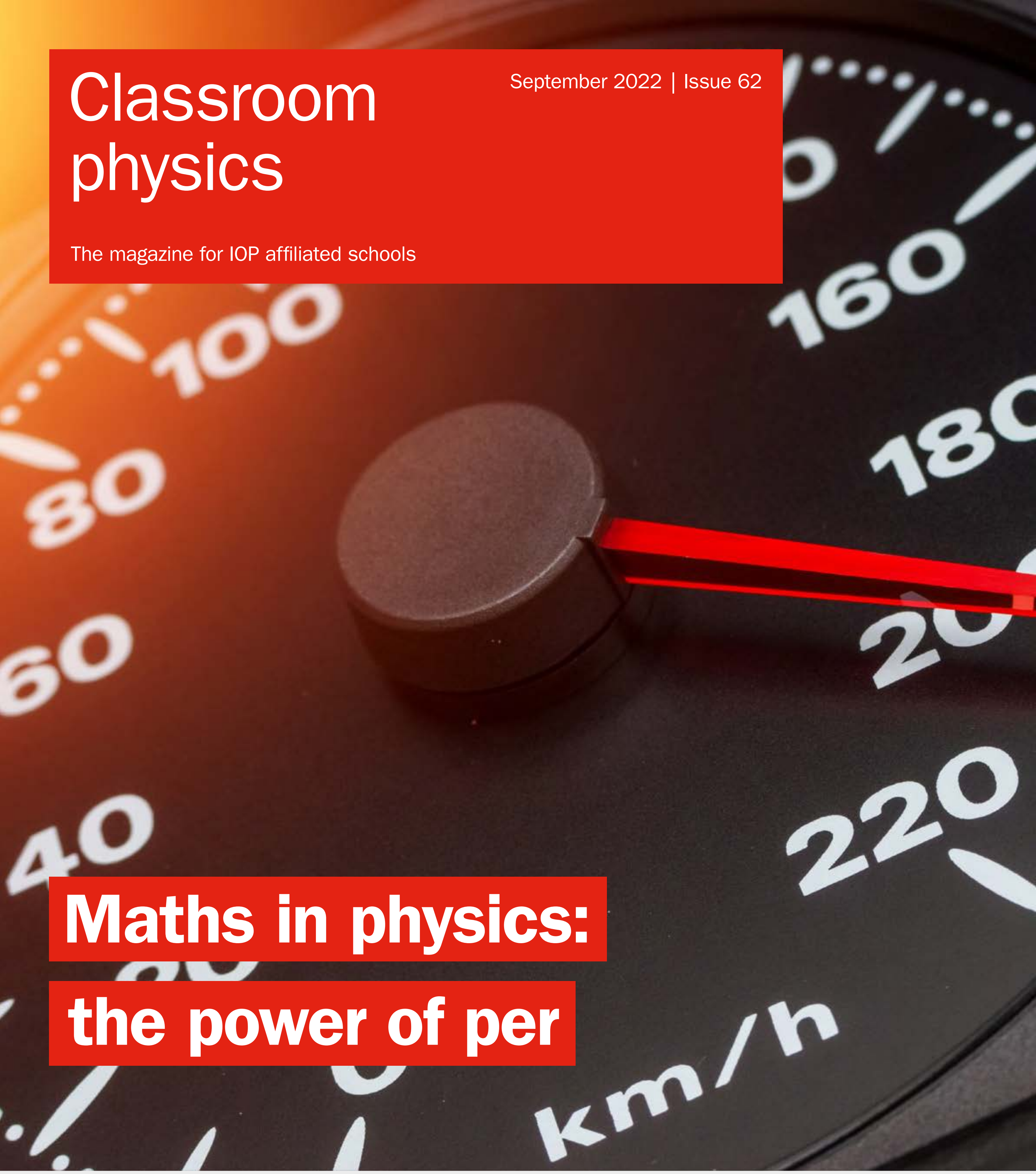
The magazine for IOP affiliated schools



Maths in physics: the power of per

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Credit: Dotted Yeti/Shutterstock

The miraculous appropriateness of maths for the formulation of physics is a gift

The unreasonable gift of mathematics

"Physics isn't something that girls tend to fancy … There's a lot of hard maths in there that I think that they would rather not do."

There was an outcry earlier this year when Katharine Birbalsingh, chair of the Social Mobility Commission, made this statement to a committee of MPs.

As an assessment of girls, Ms Birbalsingh could not be more wrong. But she does highlight a barrier to physics for many students (and sometimes their teachers).

Almost all students choosing physics post-16 also select maths.* But younger students have no choice. Ensuring they have the right mathematical skills and can apply them appropriately in their physics lessons can be a challenge.

This issue of Classroom Physics is here to help. IOP's Mark Whalley reviews a book all physics teachers should read (p 6) whilst Charles Tracy muses on which mathematical techniques are needed in school physics (p 7). Our pull-out (p 9 – 12) takes a pedagogical approach to rates and gradients, offering a powerful tool to help students with calculations and scaffolding for graph-drawing.

There is a classic classroom-ready activity for teaching the trigonometric relationship between the horizontal and vertical components of a force (p 14), whilst our colleagues in chemistry suggest baking as a recipe for mathematical success (p 17).

Physics is not maths, but physics relies on maths for part of its identity. Statistician-philosopher Deborah Mayo explains physics is so maths-heavy because we are the severest testers. We make specific predictions that need numbers. However much we might try to steer away from the plug-and-chug and concentrate on the concepts, at the end of the day we need maths. As physicist Eugene Wigner wrote in his seminal 1960 paper *The Unreasonable Effectiveness of Mathematics in the Natural Sciences:* "The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve".

Caroline Davis
Classroom Physics editor

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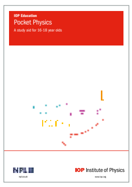
IOP Affiliated Schools & Colleges will receive with this issue…



Copies of Pocket Physics our booklet of equations for 16-19 students. Order a class-set by emailing **education@iop.org**

A Green Engineering Careers poster produced by the IOP in partnership with professional engineering organisations. Order a full set of four at **neonfutures.org.uk/resource/green-engineering-careers-posters**

Follow us on Twitter **@IOPTeaching**

Read Classroom Physics online and access previous editions at **spark.iop.org/classroom-physics**

Do role models work?

Role Model Week 2022 takes place 10 - 14 October and is part-sponsored by IOP. But how effective are role models in inspiring young people? The Limit Less campaign's Georgina Philips investigates.

We tell young people that physics is for everyone, but how do we actually make them feel this is possible? Often, we invite speakers into schools to share their experiences as role models.

Although they may seem inspiring, one-off events have been found to not have a lasting impact on young people's aspirations and outcomes. However, if part of an integrated programme and a whole-school approach, bringing in role models - particularly those who are local or share demographic characteristics with your students - can make an impact. The IOP's Opening Doors report in 2015 shares best practice, including: "Schools should try to ensure that role models are prepared to commit to a series of visits to the school, which will allow the development of constructive relationships with the pupils."

A 2018 study by the Institution of Engineering and Technology found that 1 in 4 children do not have role models, and rather than turning to teachers and parents for careers advice, nearly half of the children polled turned to YouTube instead. Here's the lived experience that a young Asian woman shared with us:

"I was a little girl who liked to learn 'boyish' subjects such as physics and maths. I quickly realised that I didn't know anyone working in a STEM field except my GP or my dentist."

The Education and Employers Taskforce found that students who experience four or more employer encounters (eg career talks, job fairs etc) will earn on average 18% more by the time they are 30. Young people start making decisions about what is not for them as early as primary school, so start conversations around jobs and careers early.

As part of the Limit Less campaign, the IOP has partnered with Founders4Schools (F4S), a charity that connects young people and their educators with a network of inspirational volunteer role models.

F4S have an online platform allowing educators to connect their students with volunteer role models easily and for free. You can create events (online or in person) and select by gender, school subject, business field and location. Last year F4S held its first Role Model Week, including the Ada Lovelace Day webinar which can be viewed online.

more...

Register your school for Role Model Week
founders4schools.org.uk/about/role-model-week

IOP Limit Less careers resources
iop.org/careers-physics/careers-resources

Read Opening Doors at
iop.org/opening-doors

Planet Possibility – opening young people's eyes to physics

A drive to attract young people - especially from under-represented groups - to consider careers in physics has been launched with a new stream of IOP funding.

Planet Possibility is the first initiative funded by the IOP's Challenge Fund. The project will challenge misconceptions and stereotypes that put some young people off studying and taking up careers in physics. Run by a consortium of charities, universities and business, it is a wide-ranging digital platform with a co-ordinated programme of activity.

Through events, webinars, content, games, guides, jobs, work experience, mentoring and other tools and channels, Planet Possibility will help create a flourishing physics community.

It will build networks of students, give young people access to physics specialists and role models, support teachers to teach physics in engaging and inclusive ways, and promote awareness of physics-related careers.

IOP Director of Science, Innovation and Skills Louis Barson said: "This represents an exciting new way of working for the IOP, delivering its strategy, harnessing and investing in innovative ideas to maximise the potential of physics for our economy and society."

more...

Planet Possibility is live at
planetpossibility.co.uk

Action needed to tackle physics teacher recruitment

A survey of UK head teachers has found nearly all of them are struggling to fill classroom vacancies. Added to this, overall applications to teacher training are down. And no surprises – physics is negatively affected in both cases.

In July, the Association of School and College Leaders (ASCL), published a survey which found that 95% of school heads have problems hiring staff, with physics the most commonly cited subject where recruitment was difficult, followed by maths, design and technology, chemistry and computing.

Fears that physics teacher recruitment had flatlined this year, following comments made on an edition of BBC's Question Time in July, proved unfounded and were based on a misunderstanding of the technicalities of the offer-acceptance process.

However, IOP analysis of the recruitment figures for teacher training in England suggest a significant drop from last year. Data as of 30 June showed 361 acceptances compared to 470 at the same point in 2021, a drop of 23%. Similarly, the IOP Scholarship scheme has offered almost 20% fewer scholarships compared to June 2021. The total calculated applicants are 675, down 6.4% on 2021.

IOP group chief executive, Tom Grinyer, said: "It is no surprise schools are struggling to recruit physics teachers – this is a longstanding problem and has resulted in a chronic shortage in schools.

"The IOP is leading calls on governments to address this shortage of physics teachers through a systematic and fully-funded approach to retraining and professional learning to reduce attrition. If we take concerted action, it is possible to solve this challenge and provide fair access to a quality physics education to all. This must be a priority."

more...

Read the ASCL report at **bit.ly/CPascl**

Eurekas! We found a winner

Credit: Frosting Physics

Prarthana Shukla, Dhariti Raythaththa, Anaiya Dattani and Serena Varia won the Eureka with a cake-lear implant!

Four schoolgirls from Leicester have been announced as the winners of a national IOP competition – scooping £1,000 for themselves and £250 for their school, Avanti Fields School.

Prarthana Shukla, Anaiya Dattani, Serena Varia and Dhariti Raythathatha baked a cake in the shape of a cochlear implant, impressing the expert judges by delving into the physics behind the devices helping so many people communicate every day. They scored top marks for originality and creativity, quality, relevance and spirit.

The competition was launched as part of the Limit Less campaign to improve diversity in physics. We asked students aged 11-16 to answer the question "What is the point of physics?" The judges were looking for submissions from students with a range of interests, whether arty, sporty, musical or into literature, languages or sciences, not just those already interested in physics.

The girls said the competition had changed their minds. Dhariti said: "I wasn't a fan of physics, and science isn't my strong point, but after researching this project it's definitely more interesting." Serena added, "After taking part in this competition, I realise now that physics is really very creative. I think it is something I would like to do going further."

The judging panel was comprised of journalist, broadcaster and physicist Shivani Dave; novelist and physicist Femi Fadugba; and Rachel Youngman, IOP Deputy Chief Executive. They received entries from over 180 young people and chose five runners-up and one winning entry.

The judges agreed that the entries showed the future of physics is bright and the next generation will achieve some incredible things. Rachel said:

"We were all incredibly impressed by the quality of entries submitted for this first year of The Eurekas. Our thanks go to every single young person that took part, and I'm already excited to see what next year's competition brings."

The Eurekas will return in 2023 – next year, your school could be the winner!

The Eurekas
A Limit Less Challenge

more...

theeurekas.co.uk

Exoplanets with the James Webb Space Telescope

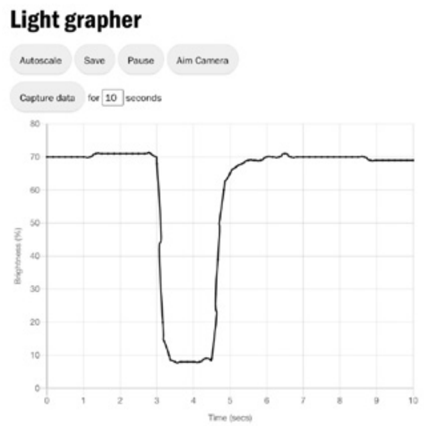
We're entering a new era of astronomy with the launch of state-of-the-art telescopes, such as the James Webb Space Telescope (JWST). These will enable us to observe and explore areas of the universe we previously could only have imagined.

One of JWST's main uses will be to examine exoplanet atmospheres to search for the building blocks of life elsewhere in the universe. Alongside spectroscopy, they will be using the transit method which looks for a dip in light from a star as the planet passes between us and the star.

The telescope had already generated excitement globally before its launch in December and the first images began arriving in July. We have some great activities for your students to model what the telescope is doing and get an understanding of what NASA is doing.

In ***Detecting exoplanets,*** students attach a ball to the top of a skewer and move it across the front of a lamp, between the lamp and a laptop. The lamp acts as the star and the laptop webcam acts as the detector (observers on Earth). This will produce a transit light curve, as in the example to the right. We used an onion as the planet for this transit light curve - we recommend you use the proper equipment when you have a go!

The ***Exoplanet atmospheres*** activity models how we can detect which chemicals are present in a planet's atmosphere and look for biosignatures, characteristics that are caused by life interacting with the atmosphere.



more...

NASA article on JWST
webb.nasa.gov/content/science

Detecting exoplanets:
spark.iop.org/detecting-exoplanets

Exoplanet atmospheres:
spark.iop.org/exoplanet-atmospheres

Full exoplanets collection:
spark.iop.org/collections/teaching-exoplanets

Equity, diversity and inclusion work in Scotland

A significant part of IOP's nearly two decades of Improving Gender Balance work was the Scottish IGBS pilot project.

We worked with six secondary schools and their associated primaries. The success of this pilot led to it being included in the Scottish Government's STEM Education and Training Strategy 2017-2022 with Education Scotland's Improving Gender Balance and Equalities team being tasked with facilitating its roll-out to all Scottish schools.

The strategy has now been extended for a further two years and it is important this work continues, as affecting deep cultural change takes considerable effort over a long timescale. Biases often begin at a young age and IGBS showed the importance of schools working together on a cluster basis and with families, which is easier to establish in early learning centres and primary schools than leaving it until pupils reach secondary school.

The required culture change goes beyond gender and the IOP's Limit Less campaign is working to remove barriers for other under-represented groups. This requires a united effort from us of all, including parents, teachers, the media and our governments. This is also very much consistent with the current focus on the United Nations Convention on the Rights of the Child and on addressing race equality within Scottish education.

IOP firmly believes that all areas of society benefit from having diverse participation and that physics is for everyone regardless of their background or gender. Although the percentage of those studying Higher physics who are female has been stuck around 27% for many years, IOP's improving gender balance projects have demonstrated this need not be the case. It is essential we address outdated ideas so that all young people are encouraged to, and have the opportunity to, learn physics, as should be the case for any other subject.

Stuart Farmer
IOP Scotland Learning and Skills Manager

more...

This article first appeared in the TES
bit.ly/CPscotgender

IGBS can be downloaded from Education Scotland at **bit.ly/CPigbs**

Race Equality and Anti-Racism in Education Programme **bit.ly/CPantiracismed**

Book review:

Yes, But Why?

By Ed Southall

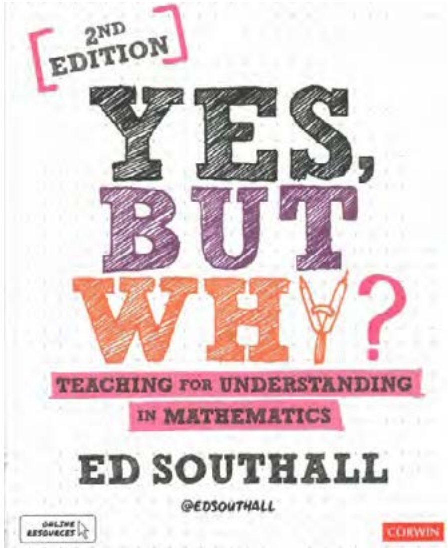
Let me start by saying I love this book! I am a physics and maths teacher and I first read *Yes, But Why?* in 2017. It was a leaving gift from a school - though maybe they were telling me something about my maths teaching!

Even though it is not our job to teach mathematics, *Yes, But Why?* has a lot to offer physics teachers. The primary audience for this book is maths teachers and those training to teach and it answers lots of the basic questions at the heart of the maths taught in schools. However, sometimes we do have to teach mathematical methods in physics lessons and we may end up using what we learned when we were at school rather than the methods being taught just down the corridor. Ed's book is a good way to find out what is being taught as well as how we can support our maths colleagues.

Particular highlights include the algebra chapter, which includes function machines. Most students are familiar with these and they provide a valuable teaching tool when changing the subject of an equation. The *Statistics and Probability* chapter reveals how maths teachers deal with graphs and plotting data, enabling physics teachers to be on the same page as the students when they talk about correlations and we talk about lines of best fit. Another section on averages discusses Anscombe's quartet – four different data-sets resulting in the same mean - demonstrating the impact outliers.

The entire book is well worth reading, providing fascinating background to anyone with an interest in maths. It is also something to have on the prep room shelf for colleagues struggling with teaching the mathematical elements of science.

Mark Whalley
IOP Manager for Learning



When do I teach why?

Since the *Teaching for Mastery* programmes were introduced nearly ten years ago, the influence of the approach is easy to see.

Maths Hubs have been hard at work with training programmes, perhaps most successfully in primary schools, steering teaching away from procedural methods and towards a conceptual understanding of the subject.

In practice, this means that teachers prioritising more thorough teaching of topics with the aim of making maths make sense, rather than 'just' ensuring that students can follow algorithms and use tools proficiently. This has been a welcome adjustment, requiring significant retraining in how mathematics is taught and in teachers' subject knowledge development. However, little attention has been paid to *when* we should focus on more conceptual explanations in our teaching.

Here, sequencing requires considerable thought and nuance to get right. Should sequencing be done badly, we risk overwhelming students with so much new knowledge they may not know what specifically they are supposed to be learning, or even be able to do so due to cognitive overload. Furthermore, conceptual explanations are often so much more complicated than the process or algorithm we are trying to teach, that we can end up teaching far more content, imprecisely. We risk demotivating and confusing our learners - the opposite of what we are trying to achieve.

Conceptual understanding of the sciences is really important. It helps connect topics, allows for wider and more flexible understanding beyond superficial 'it looks like x so I solve it like y' approaches, and over time significantly reduces how much students need to memorise. It is essential for effective problem solving and application of knowledge, but it is not easy to accomplish or teach.

There is no simple answer to 'when do I teach *why?*', but there are some factors that can help with decision making about sequencing:

1. Is the conceptual explanation simple?
2. Does the conceptual explanation significantly add to cognitive load?
3. Does understanding of the conceptual explanation require new knowledge?

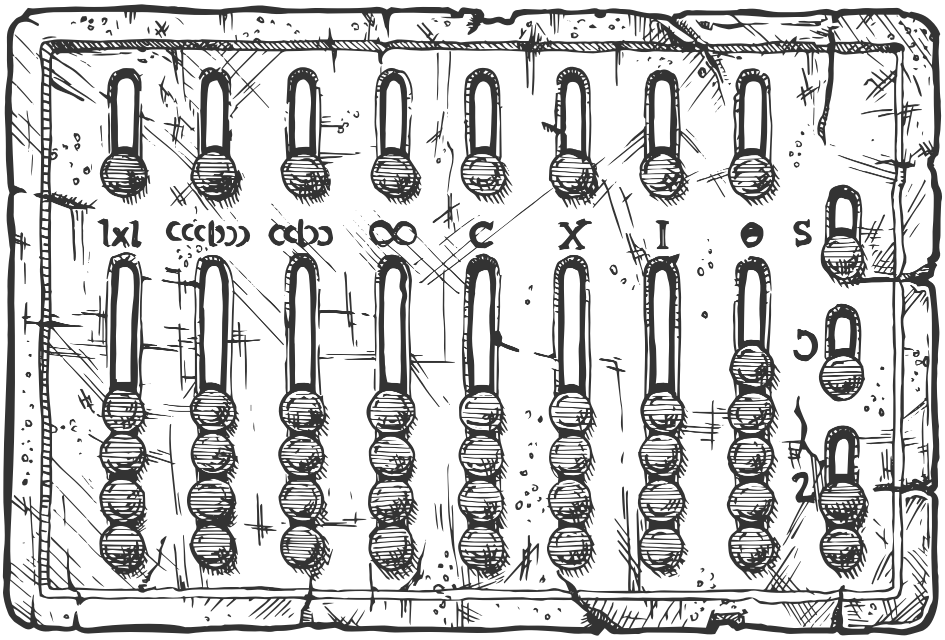
Good teaching should seek to explain and make sense of difficult and complicated ideas by making them feel simple or easy to grasp. This in turn creates buy-in for those moments where compromise is inevitable and we have to settle for letting our students know that a concept isn't magical, but its explanation goes beyond where we want to take them at this point in their learning.

Ed Southall is a teacher of mathematics, curriculum manager at Oak National Academy, teacher trainer and author **@edsouthall**

more...

This is an abridged version of Ed's article. Read it in full at **spark.iop.org/when-teach-why**

Recurring quantitative techniques in physics



Credit: Babich Alexander/Shutterstock

Roman abacus. Human civilisations have been using mathematical reasoning for thousands of years. Modern physics draws on a range of quantitative techniques

Physics relies intimately on techniques for dealing with numbers. Indeed, physics may be the only university degree course that requires entrants to be successful in two specific level 3 qualifications: physics and maths.

It is tempting, therefore, to say that physics uses maths or, more disparagingly, is “simply applied maths”. However, such assertions do a disservice to both disciplines. They both use numbers and quantitative techniques. But often in different ways. And, given that many of the techniques are either unique to physics or unique in the way that they are used, we should regard them as part of physics itself. They are certainly integral to the ways of thinking and reasoning like a physicist.

It is often said that one of the beauties of physics is that you need to know and be able to do a small number of things well; and, once you have those capabilities, you can apply them in many situations. And this adage applies to the quantitative techniques of physics - the number of techniques is reassuringly small and they recur throughout the discipline – across both the domains and age ranges.

Therefore, it is going to be helpful to identify and itemise its techniques so that they can be explicitly included in lesson sequences. In that way, students can practise them in a progressive and scaffolded way – along with the other recurring ideas that make up the disciplinary knowledge of physics.

So, here are some proposals for the main quantitative techniques of physics:

a) approximation and order of magnitude calculations
b) extreme case reasoning
c) developing operational definitions
d) algebraic reasoning
e) proportion and inverse proportion
f) ratio and compensation
g) change over time
h) rates and accumulation
i) exponential.

Fluency in using these techniques is a valuable, transferrable capability that is part of the enduring advantage (for employment and for study) of having studied physics. Additionally, including these in a physics education, alongside other aspects of the practices of physics, has cultural importance. It can help develop an enduring and authentic sense of what physics is, and the power and reliability of its explanations. That is, to reinforce, through experience, the sense that physics explanations are more than opinion or whim – they are grounded in observation, analysis, thought and reasoning, much of which relies on the quantitative techniques above.

Many physics explanations are rooted in numbers. In physics, we tend to define quantities and then look for verifiable quantitative relationships between them. To give a sense of the prevalence of quantities in physics, the IOP has published a glossary of the 33 most common quantities at school level. And we have a list of over 60 without being at all esoteric.

Those relationships have survived because they can make measurable predictions that have been severely tested over centuries – partly thanks to their applicability and utility in engineering and design.

So, in summary, the explicit development of these quantitative techniques, through practice, will provide students with both a hugely prized set of transferable skills and an enduring and, we hope, positive, view of physics.

more...

spark.iop.org/collections/glossary

ase.org.uk/system/files/SSR_September_2018_36-43_Tracy.pdf

Physics education research

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.

Get involved with physics education research discussions by joining the **Physics Education Research** group on Talk Physics at **talkphysics.org/groups/physics-education-research-per** or email **research@teachphysics.co.uk**

The problem of problem solving

Solving quantitative problems is central to being a physicist and hence a significant element of physics classroom practice.

However, research has shown that students can be able to perform the steps in a problem-solving process and produce the correct answers whilst lacking a full understanding of the concepts involved. What we would like is to consistently ensure our students aren't just plugging-and-chugging but are engaging with the concepts of physics in a meaningful way.

In a 2015 paper, Docktor, Strand, Mestre and Ross attempted to address this by applying the Conceptual Problem Solving (CPS) framework, developed by Leonard, Dufresne and Mestre, to school physics teaching.

CPS begins from the assumption that novices tend to solve problems by focusing on the selection and manipulation of equations.

Experts start from an identification of general principles, can describe an overarching approach (for example, solving via minimisation of energy) and give a rationale for their choices.

Docktor's team asked students to:

a) set out the major principle underlying a problem

b) justify why that principle is relevant

c) set out a procedure that applies the principle to the problem context to produce a solution (the "what, why and how" of solving a problem).

Solutions are expected in a two-column format: the stages of the plan in one and the matched equations, rearrangements, substitutions and diagrams in the other. Students are not required to write the principle, justification and plan before carrying out the quantitative solution although most students did, as did the teachers when sharing examples. The rationale for the structure was to highlight the role of conceptual knowledge in problem solving – this can be activated before, during or after, numerical manipulation.

The authors report that, in general, students taught using the CPS approach achieved more highly than their traditionally taught peers. The authors cautiously conclude that there is an advantage to the CPS over approaches which emphasise the manipulation of equations alone.

Sample problem and strategy

Problem: A 350kg rollercoaster car, loaded with passengers, starts from stationary at the top of a 6m drop. What will its speed be when it reaches the bottom of the drop?

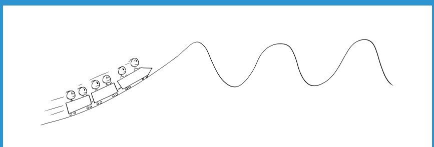
Principle: Conservation of energy: the total energy of an isolated system is the same in the initial and final states.

Justification: Neglecting air resistance and friction there are no external forces acting on the roller-coaster. Therefore, no energy is gained or lost between the top and bottom of the drop. The total energy of the car at the top and bottom of the drop are equal.

Credit: Zdenek Sasek/Shutterstock

Plan:

1. Draw a picture and assign symbols for quantities in the problem. Choose a coordinate system.



2. Write an equation for total energy at the top and bottom of the drop, considering the energy stored both gravitationally and kinetically.
3. Solve for the final speed of the rollercoaster car. Substitute values and calculate a numerical answer.

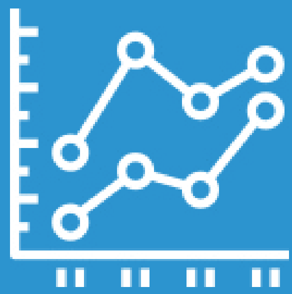
more...

Docktor et al's paper *Conceptual problem solving in high school physics* can be downloaded at: **journals.aps.org/prper/pdf/10.1103/PhysRevSTPER.11.020106**

Pull out and keep!

Maths in physics

Ratios and graph plotting



Inside this issue:

- Teaching approach: the power of per
- Activity: scale strips

Build good maths habits early

Who hasn't used seemingly basic mathematics in a physics lesson only to be met with a sea of blank faces? Or a refusal to admit they have ever seen such a thing before? Not to mention students balking when faced with rearranging equations – in fact, maybe you are not that comfortable with them yourself?

A collaborative relationship between maths and physics departments can be extremely beneficial for learning. Our top tip is to get a maths buddy, meet up regularly and discuss what topics you will be covering next. Develop a consistent approach to teaching graph plotting, rates and ratios. Identifying physics equations that can be used for examples in maths lessons can also help students make links between the subjects. In this pull-out, we tackle two essential areas of maths used in physics from the start of secondary school.

For examples of science and mathematics departments working together read *Language of Mathematics in Science: ASE Teaching Approaches* at **ase.org.uk/mathsinscience**

The power of per

Rates and ratios are ubiquitous, from atmospheric carbon-dioxide in parts per million to vehicle emissions in grams per kilometre and from food labels in calories per gram to pandemic data in cases per day.

That little word 'per' is key and understanding what it means is critical to becoming a scientifically literate citizen. Many of your students will not continue with science post-16, so they need to get a solid grip on the meaning of this word early in secondary school.

The traditional approach to calculations in physics can be a barrier. In the process of selecting an equation, re-arranging and substituting values, the meaning of the word can get lost. So we have developed an alternative approach for students who struggle with equations called the **Power of Per** (page 10). We focus on developing an intuitive understanding of the units first, by saying things out loud and using verbal reasoning to arrive at the answer before moving onto maths proper.

Scaffolding graphs using scale strips

Another important maths in physics skill is interpreting graphs. For climate change, it's not the value of the global temperature today that is most important, but the rate of increase represented by the gradient of a temperature-time graph.

But don't rush into teaching gradients and areas under curves without first checking that your students have the basics. It's easy to think that when they arrive at secondary school they will have a reasonable grasp of how to plot a graph. And many will. But they will have had differing experiences and, of course, some will have forgotten how to plot a graph over the summer while others might not have grasped the process in the first place. Spend some time laying the foundations.

The **Scale Strips** activity on page 11 provides a scaffolded approach plus a **Graph Checklist** to help students critique their own graphs and those of their peers.

Mark Whalley is the IOP's Manager for Learning

Liz Nourshargh and Eleanor Wylie are IOP Professional Support Coaches

Teaching approach: The power of per

This method of working through calculations relies on unpicking the meaning of the units and verbal reasoning. Use it to unlock the meaning of that very powerful little word 'per'

Let's consider this exam style question:

A cement mixer is a special lorry that delivers cement in liquid form. Cement has a density of 2400 kg/m³. A total of 9600 kg of cement is delivered to a building site. What volume container is needed?

Rather than going straight for a calculation, ask your students to:

1. **Say the units out loud**
   "Kilograms per cubic metre"

2. **Replace "per" with "each" or "for every"**
   "Each cubic metre of cement has a mass of 2400 kg" or "there is 2400 kg of cement for every cubic metre the concrete fills"

3. **Reason out the answer**
   "The mass of 1 cubic metre is 2400 kg, so the mass of two cubic metres is…"

4. **Create a table**
   Once your class are confident in their understanding of what the units are and what that means, ask them to make them into a table and see if they can find the pattern. They should notice that **volume x density = mass**

Volume	Density	Mass
1 m³	2400 kg/m³	2400 kg
2 m³	2400 kg/m³	4800 kg
3 m³	2400 kg/m³	7200 kg
4 m³	2400 kg/m³	9600 kg

5. **Try the maths**
   Now show them the symbols and the formula $V \times \rho = m$ and run through the question again mathematically. Both times, they see the answer is that the site will need a container with capacity of at least 4 m.

VIPs: Very Important Pers

- velocity – metres **per** second (m/s)
- frequency – **per** second (/s or Hz)
- current – coulombs **per** second (C/s)
- power – joules **per** second (J/s)
- potential difference – joules **per** coulomb (J/C)
- pressure – newtons **per** square metre (N/m²)
- density – kilograms **per** cubic metre (kg/m³)
- gravitational field strength – newtons **per** kilogram (N/kg)
- specific latent heat – joules **per** kilogram (J/kg)
- spring constant – newtons **per** metre (N/m)

Double pers

- acceleration – metres **per** metre **per** metre (m/s² or m/s/s)
- specific heat capacity – joules **per** kilogram **per** degree (J/kg/°C)

Teachers' notes

The benefit of this approach is reducing cognitive load as there is no need to recall a formula. It also avoids students blindly plugging numbers into a formula, instead they engage with the language and understanding of the concepts before tackling the numerical part. Start by keeping the numbers simple with a whole number answer. It can be used for any calculation involving a quantity whose units are a ratio of two quantities. For example, the units for speed are metres per second (m/s), combining the units of distance (m) and time (s).

Use the example below to open a discussion about climate change and talk about green engineering careers:

A typical small petrol driven car has CO_2 emissions of 100 g/km.

a. How much CO_2 does the car emit in a journey from Land's End to John O'Groats, a distance of 1350 km?

b. How far do you have to drive to emit 1 kg of CO_2?

Start by asking, "What does 100 g/km mean?" Students may be surprised that even a small car can emit 100 g of CO_2 for every kilometre travelled. Follow the steps above to find the answers both ways (a. 135,000 g or 135 kg and b. 10 km). Now make the link to STEM careers using the green engineering poster included with this issue of Classroom Physics.

more…

Order the full set of four green engineering careers posters at **neonfutures.org.uk/resource/green-engineering-careers-posters**

Activity: Scale strips

Choosing sensible scale intervals is something that students struggle with. Some choose gaps of 3 rather than 5 when drawing axis markers, while others bunch up the data at one end of the graph paper. Scale strips help scaffold learning by providing a limited number of options to choose from.

Preparation

Before the lesson, make sets of scale strips for each group of students by copying page 12 onto paper or card (if printing, ensure your printer is set to 100%), cutting out the strips and hole-punching them. You may want to colour code them with sticky dots, stamps or highlighters. Connect them with string to complete each set. To make them more robust, laminate the strips before hole-punching. If your school's graph paper is different to our template, make your own by copying the information on page 12 onto your preferred graph paper and you could use different coloured pens for each axis to make them easier to identify. Your students could make a set of scale strips themselves as part of the activity, but watch out for hole-punching as it can easily go wrong!

Equipment

Each group of students will need:

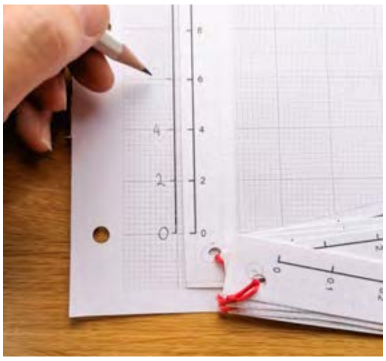
- set of scale strips (see *Preparation* above – you'll need and string)
- graph paper
- 30 cm rulers
- sharp pencils
- experimental data on board (use this data which is for a stretched spring or provide your own)

Force / N	**Extension / cm**
0	0
4	2
8	4
12	6
16	8
20	16
24	32

Procedure

Ask students to:

1. Look at the sample data and identify the largest values to be plotted on the y-axis (for the sample data above it's a force of 24 N).
2. Choose the scale strip whose highest value is closest to the largest y-axis data value (eg the strip with intervals of 2).
3. Draw a y-axis near the edge of the paper and place the strip against it to mark intervals on the y-axis (see image).
4. Label the axis with the quantity and units.
5. Repeat for x-axis data.
6. Plot the graph.



ABOVE: Making a set of scale strips.

LEFT: Using a set of scale strips.

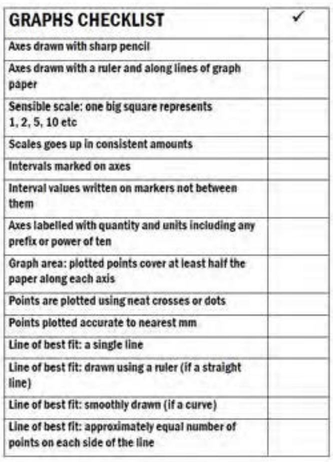
Teachers' notes

Some students may be tempted to use the scale strips as a straight-edge for drawing axes. Remind them to use a ruler.

Once students have worked through one example, they can use the scale strips to plot their own experimental data. Remind them to consider whether to use the graph paper portrait or landscape. It isn't always best to plot the y-axis data along the long side of the paper.

Teaching tip

Our graph checklist can be used by students of all ages to check and critique each other's graphs.



GRAPHS CHECKLIST	✓
Axes drawn with sharp pencil	
Axes drawn with a ruler and along lines of graph paper	
Sensible scale: one big square represents 1, 2, 5, 10 etc	
Scales goes up in consistent amounts	
Intervals marked on axes	
Interval values written on markers not between them	
Axes labelled with quantity and units including any prefix or power of ten	
Graph area: plotted points cover at least half the paper along each axis	
Points are plotted using neat crosses or dots	
Points plotted accurate to nearest mm	
Line of best fit: a single line	
Line of best fit: drawn using a ruler (if a straight line)	
Line of best fit: smoothly drawn (if a curve)	
Line of best fit: approximately equal number of points on each side of the line	

Download at **spark.iop.org/ graphs-checklist**

Scale Strips

Cut along here

1.2	2.4	6.0	12	24	60	120	240	600	1200
1.1	2.2	5.5	11	22	55	110	220	550	1100
1.0	2.0	5.0	10	20	50	100	200	500	1000
0.9	1.8	4.5	9	18	45	90	180	450	900
0.8	1.6	4.0	8	16	40	80	160	400	800
0.7	1.4	3.5	7	14	35	70	140	350	700
0.6	1.2	3.0	6	12	30	60	120	300	600
0.5	1.0	2.5	5	10	25	50	100	250	500
0.4	0.8	2.0	4	8	20	40	80	200	400
0.3	0.6	1.5	3	6	15	30	60	150	300
0.2	0.4	1.0	2	4	10	20	40	100	200
0.1	0.2	0.5	1	2	5	10	20	50	100
0	0	0	0	0	0	0	0	0	0

Hole punch here

Maths in physics

The story of an equation

The most famous equation in science, $E=mc^2$, has a fascinating back story. The image of Einstein as a lone genius producing the equation in isolation masks a richer, collaborative and iterative history – as is common in the development of physics.

In 1881, JJ Thompson proposed a model of the magnetic field generated by a moving electron, observing that the field might induce an increase in the particle's mass. Thompson's model was simplified by Oliver Heaviside in 1889 to $m = (4/3)\, E / c^2$.

Heaviside's contribution is notable because he was one of a handful of physicists critical of relativity theory – and he gets a namecheck in the musical *Cats* which mentions the Heaviside layer, a section of the Earth's ionosphere.

Henri Poincaré imagined the motion of a sphere through a 'fictious fluid' and used John Henry Poynting's notion of energy conservation to state that: $E = mc^2$. Poincaré, however, assumed that the result applied only to imaginary bodies.

In 1904, a year before Einstein, Lorenz proposed the relationship $m_L = m_0 (1 - v^2/c^2)^{-3/2}$. In the same year, Friedrich Hasenöhrl derived the increase in apparent mass of a moving cavity containing electromagnetic energy as $E = 3/8\ mc^2$ which he then corrected to $E = 3/4\ mc^2$. It is unclear if Einstein was aware of Hasenöhrl's work but the two men certainly met at the 1911 Solvay conference.

Isaac's errors

Whilst Newton made significant contributions to many areas of physics, like all of us, he also made a number of errors.

The first edition of *Principia* ran to only around 300 books. Soon after publication, Huygens, Bernoulli and Leibniz noted errors in the text and Newton himself kept a version of the first edition in which he noted amendments. His attitude to his mistakes reflected a rather aloof position: *"Such errors as do not depend upon wrong reasoning can be of no great consequence & may be corrected by the Reader".* Bernoulli pointed out a number of errors, including Newton's argument that a vertical jet of water will reach half the height of the head of the supply, a result that was falsified by experiment.

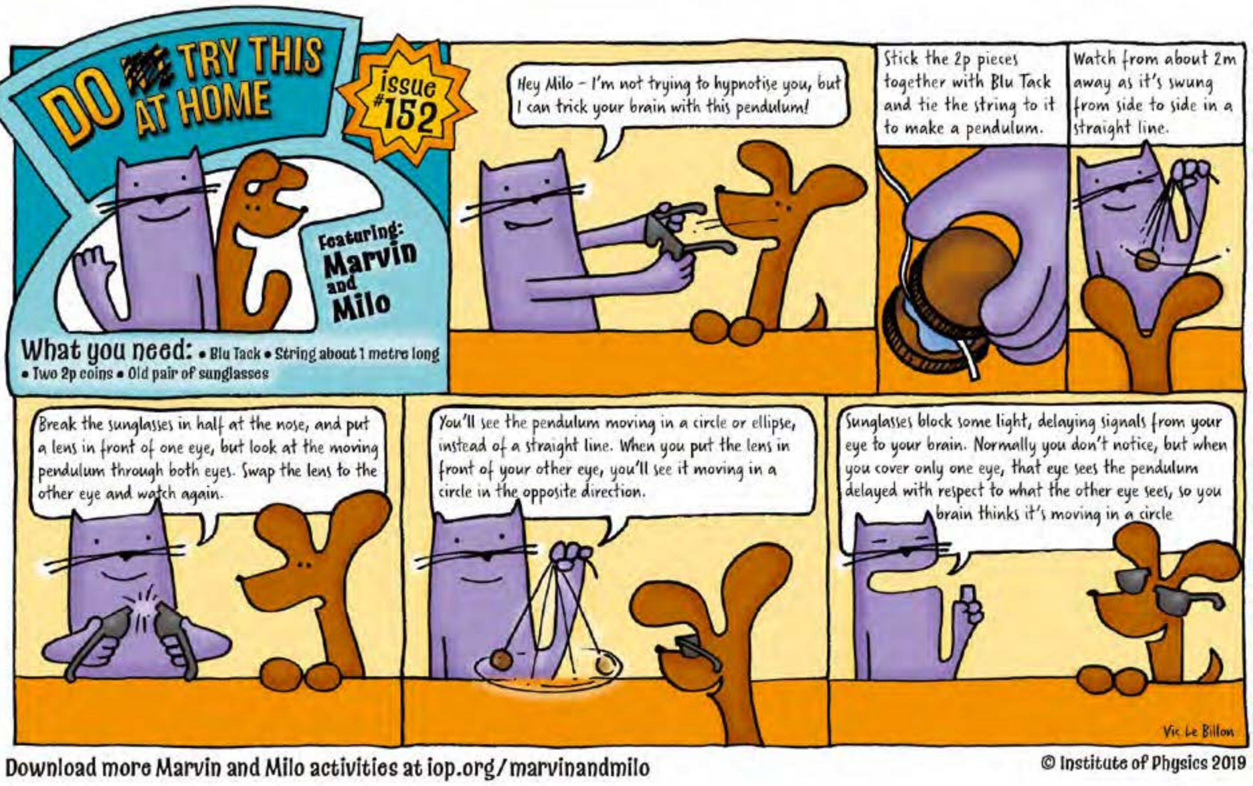
Other slips include an incorrect statement of the rate of flow of liquid leaving the bottom of a container; a mistake in a calculation of the Earth's wobble; the use of an incorrect value of the Earth's radius; and an erroneous conclusion that the moon was $1/40^{th}$ of the mass of the Earth rather than $1/81^{th}$.

Whilst a survey of Newton's errors might feel churlish, I find the observation that even the greatest minds make mathematical slips is reassuring and might be valuably highlighted to students.

spark.iop.org/stories-physics

These stories were collected by Richard Brock, lecturer at King's College London and former physics teacher.

Follow him on Twitter **@RBrockPhysics**



Physics*education*

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

Editor-in-chief Gary Williams highlights his favourite papers on **maths** from the archive and the current volume.

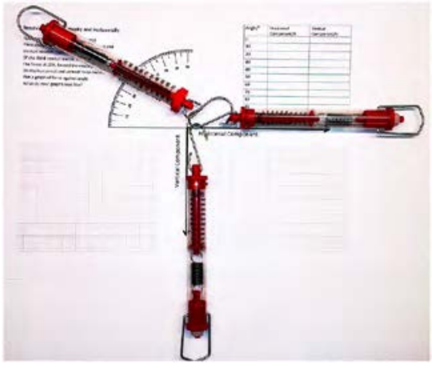
Access over 50 years of articles at **iopscience.org/physed.**

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

A classroom ready activity

If you haven't seen it before, *A practical activity for teaching the trigonometric relationship between the horizontal and vertical components of a force* will save you some work. This 2015 article has explanations and tables ready for use in the classroom. Arrange three newtonmeters then measure the angles between them and the force readings on the meters. This allows the trigonometric relationship to be seen. I tried something similar using trouser braces. I drew an arrow on each of the three straps and measured their size as an indication of the size of the force as the elastic stretched, measuring the angles between the straps where they joined. It sort of worked… I blame lack of foresight by brace manufacturers for the error in our measurements.

bit.ly/PEDtrigforces



Credit: Physics Education

Three newtonmeters joined together and ready for action

Standards

The title of the 2012 paper *An analysis of the changes in ability and knowledge of students taking A-level physics and mathematics over a 35 year period* says most of what you need to know. The University of Bristol tested incoming physicists with the same test for 35 years and the author compares their scores to their A-level grades. The conclusion is that whilst standards might not have slipped, they have certainly changed. There is an obvious change during the 1990s and the cause seems to have been changes in schools with knock-on effects hitting universities. As the education systems in the UK continue to diverge, this is worth a read and some thought for when we are next asked our opinions on curriculum changes.

bit.ly/PEDstandards

Understanding

Many of us assume that what we understand when we see an equation is what our students will also understand, if they have grasped what we have taught them. We know they are not empty vessels waiting to be filled with knowledge. Didactic transposition happens and what is in the curriculum is altered by teachers and then re-interpreted by students. If we do a good job, there is some similarity between what the students have learnt and what the curriculum writers expected to be taught. But the maths in the physics curriculum is not always explicitly stated. In the paper *What does 'I understand the equation' really mean?* author Richard Hechter asked his students what they meant by saying yes they understood his equation. It makes many interesting points.

bit.ly/PEDunderstand

Infinity

There are some interesting discussions to be had about what undefined mathematical terms mean in physics, for example dividing by zero. Recent papers *Infinity: some close encounters in physics teaching* and *Infinity, self-similarity, and continued fractions in physics: applications to resistor network puzzles* explore challenges with well-defined terms, like working out the resistance of an infinite number of resistors.

bit.ly/PEDinfinityencounters

bit.ly/PEDinfinitypuzzles

Physics*education*

Credit: Physics Education

50 different self-avoiding walks embroidered on a 30 cm embroidery hoop

In stitches

I greatly enjoyed reading *SAWstitch: exploring self-avoiding walks through hand embroidery,* a paper about embroidery and how it could be used to demonstrate random walks. The work was done as part of public engagement activities but it could easily be transferred to the classroom. The paper also discusses ideas about social structures. It considers how there might be a number of 'tribes' with different values and ideas that might need specific approaches to combat alienation from STEM subjects. It seems there are more than CP Snow's *Two Cultures*. This is an Open Access paper so free for anyone to read.

bit.ly/PEDSAWstitch

Problems

There are many problems to solve when it comes to physics from lack of diversity to actual written problems. *Additional unexpected benefits of rewarding students for effective problem solving strategies: supporting gender equity in physics* looks at both of these. By rewarding students for their use of steps in problem solving rather than just rewarding the right answer, the authors discovered an improvement in gender equity. "Our findings suggest that awarding appropriate credit to the entire problem solving process, eg by giving credit for drawings and scratchwork, may support gender equity in physics." In a way this takes this article full circle, back to the mention of standards on the adjacent page. We don't need to lower the bar. We need to widen it.

bit.ly/PEDproblems

Quick Links

A physical model to simulate the photoelectric effect

bit.ly/PEDphotoelectric

Motion of a plucked string or spring

bit.ly/PEDpluckstring

Phenomenological optics with self-made liquid lenses in the physics classroom (Open Access)

bit.ly/PEDliquidlenses

Demonstrating acoustic camouflage with ultrasonic sensors in the laboratory

bit.ly/PEDacousticcamo

Experiments for students with built-in theory: 'PUMA: *Spannungslabor*' – an augmented reality app for studying electricity (Open Access)

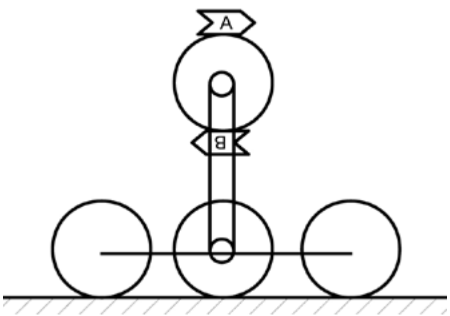
bit.ly/PEDpuma

On the merits of a unified physics and engineering undergraduate programme of study (Open Access)

bit.ly/PEDphyseng

The Hanstead Car

Credit: Physics Education



A simplified Hanstead car: when rockets A & B fire, the upper wheel turns clockwise and drives the car toward the right

I am indebted to the author of *On the operation of the Hanstead car* for bringing this idea to my attention. The original article on the Hanstead car, *A paradox in mechanics?*, appeared in 1966 in the first volume of *Physics Education*. Despite having original paper copies that I have looked at numerous times, I somehow managed to miss this little gem. It is a simple idea: "Two rockets, labelled A and B, are firmly attached to a wheel on opposite sides. The axle of the wheel is connected to that of an identical wheel on the ground by a belt (or some other suitable drive train)." The 2022 paper describes discussions about what happens when the rockets are in various states. This idea could be used at a number of levels with students. This is an Open Access paper, so even students can download it.

bit.ly/PED2022hanstead

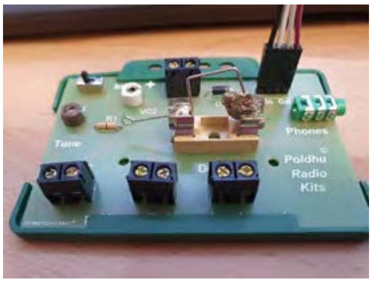
bit.ly/PED1966hanstead

talkphysics

David Cotton, editor of our online discussion forum, chooses his favourite TalkPhysics discussion threads on **maths in physics.**

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

Credit: Nick Mitchener



Crystal radio kit

Maths on Monday

A great place to start is *Maths on Monday.* This started as a series of fortnightly CPD sessions run by IOP coaches Liz Nourshargh and Mark Whalley to support science and physics teachers with the maths required by the GCSE physics specifications. The resources in this group have been very popular.

bit.ly/TPmathsmonday

Teaching logs and exponentials

As part of the IOP Domains programme, David Farley responded to requests for ideas on teaching logs and exponentials. This maths is essential for several topics in post-16 courses and yet it is often given only a brief amount of teaching time in the classroom.

bit.ly/TPlogs

Side-by-side calculations

Calculations are important in all of physics and particularly so in teaching energy conservation. The resources for this IOP Energy Domains session has examples of 'side by side' calculations for use in the classroom with students.

bit.ly/TPsidebyside

Graphs from real data

Graphs are an important analysis tool in both maths and physics lessons. This thread details an idea to generate graphs from real data in real time.

bit.ly/TPrealgraphs

Crystal radios

Not directly maths-related, but this recent thread answered a TalkPhysics user's request for ideas to bring waves for communication into their year 8 curriculum. Nick Mitchener, one of our most prolific and creative TalkPhysics users, shared his tips for building crystal radios.

bit.ly/TPcrystalradio

physicsworld

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

CreditMagic Mine/Shutterstock

Complex numbers are essential in quantum theory

Complex numbers are essential to achieve the most accurate quantum-mechanical description of nature and are more than just a mathematical convenience, according to experiments done by two independent teams of physicists. While the mathematics of complex numbers underlies modern quantum theory, it is also possible to describe the quantum world purely in terms of real numbers. As a result, it had not been clear whether complex numbers' role is crucial, or if they are simply a useful tool.

Until recently, this had been a philosophical debate. The new experiments implemented a series of quantum-information operations, manipulating light or a superconducting quantum bit (qubit). The outcomes were shown to be impossible to predict accurately by real-number quantum theory.

bit.ly/PWcomplexnos

Long-duration spaceflight is bad for the bones

A study into bone loss in astronauts returning from long spaceflights has shown that some may have incomplete bone recovery even after one year back on Earth, with sustained losses equivalent to 10 years of normal age-related bone loss on Earth.

The TBone study began in 2015, following 17 astronauts before and after spaceflight. The team used high-resolution peripheral quantitative CT to scan the tibia (shinbone) and radius (forearm) to assess bone strength, density and microarchitecture.

The results show that, after one year, weight-bearing distal tibia bones only partially recovered in most astronauts. Some who flew on missions under six months recovered more bone strength and density in the lower body compared with those who flew for longer durations.

bit.ly/PWbones

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

Credit: lidante/Shutterstock

Baking is a fun, accessible introduction to why and how we use balanced equations

A recipe for mathematical success

A vital ingredient in science teaching is showing students how to apply their maths learning. These tasty titbits will help you do just that.

From balancing equations and drawing lines of best fit to calculating moles, there's plenty of maths in chemistry. But who would have thought that baking flapjacks could be a key ingredient in a successful lesson on stoichiometry?

The concept of stoichiometry and reacting masses in chemical equations might involve relatively straightforward maths, but students can find it tricky. They might struggle with balancing chemical equations and then converting to formula masses and using simple ratios (more on those later). But equally it might not be the actual calculations they find difficult, it might be the unfamiliar context that's the barrier. The recipe for success, says Duncan Short, a chemistry teacher in Scotland, is baking.

Duncan has discovered that introducing the concept of a recipe is a relatable way into the topic of stoichiometry with his pupils -- plus it has some tasty results. Read about Duncan's approach and download his worksheet looking at ratios, excess and limiting reagents, and gram formula mass: **rsc.li/3PysFt3**

Now back to those ratios. Along with graphs, data handling, algebra, standard form and working with 2D and 3D models, it's one of those areas of maths that chemistry students need to be confident with. Which is why we put together a set of articles on effective approaches to teaching these maths topics within chemistry lessons, complete with resources to help teachers do that. And so much of it is applicable across the sciences.

Check out our maths skills articles at **rsc.li/3AZCwEm**

Download the resources: **rsc.li/3uVeWF2**

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**

HSE visits to schools: radioactive sources

The Health & Safety Executive (HSE) is planning to visit around 90 schools in England, Wales and Scotland this autumn, focusing on the safe management of radioactive sources in school science. We met with them in April to explain how radioactive sources are used in schools and the advice we give on safe use and management.

Where schools are following CLEAPSS **guide L93,** the HSE has agreed that, along with CLEAPSS supporting guidance documents, this is sufficient to meet the requirements of the Ionising Radiations Regulations (IRR17). We anticipate the HSE inspectors will want to see good evidence of how risk assessments, storage and maintenance requirements are applied in the school.

CLEAPSS supporting **guide GL016** explains how we followed the relevant parts of the HSE's Approved Code of Practice to IRR17 to produce the risk assessments in L93. Ahead of an inspection, the designated teacher responsible for the sources (the Radiation Protection Supervisor) should have a copy to hand so they can respond to HSE questions. Detailed knowledge of GL016 is not needed for teachers and technicians who use the sources. That is the purpose of L93.

We advise all schools to check source inventories and begin the process of disposal of any sources for which you have no risk assessment, eg those red-bordered in L93 or that do not appear in L93 at all. Using sources for which you have no risk assessment from your employer is a breach of IRR17. **Contact your Radiation Protection Adviser, or CLEAPSS if you subscribe, for advice before proceeding with any disposal.**

bit.ly/CLEAPSSL93

CHAT PHYSICS

ChatPhysics is a collective of physics teachers and interested parties. We promote Twitter discussions between teachers, collate original subject CPD, and share a wealth of fun and handy teaching ideas.

On Twitter **@ChatPhysics** or visit **chatsci.com/category/subjects/physics**

FIFA – it's not just football

Physics explains features of the world around us, and equations give us the power to describe them precisely. At ChatPhysics we believe that a good structure, delivered consistently, will support students' approach to calculations in physics.

Physics teacher and blogger Gethyn Jones suggests the FIFA method, which has nothing to do with football; rather, it is a mnemonic that helps KS3 and KS4 students from across the attainment range engage productively with calculation questions.

Formula: this should be selected having identified the relevant quantities.

Insert values: by substituting in the values, the equation can be simplified before rearranging.

Fine-tune: not always required but could be rearranging for the correct subject or converting to suitable units if not done so already.

Answer: this prompts students to check that their answer matches the question, such as checking the required units or ensuring that they have found the correct quantity and stated it clearly.

Formula	$\Delta E = m\ c\ \Delta\theta$
Insert values	$\Delta E = m \times 4190 \times (8 - 0)$
Fine-tune	$\Delta E = m \times 4190 \times 8$
	$\Delta E = m \times 32520$
Answer	$\Delta E = 32520\ m$

Unfortunately for many, formula triangles have led to a false sense of security. They are often not credited in exams and detach understanding from the relationship between the quantities. We feel that they should mostly be avoided, particularly in first teaching, but may be useful support for some students as exams approach.

Gethyn's blog on FIFA **physicsteacher.blog/tag/fifa-calculation**

ChatPhysics Live 2021 video on moving away from formula triangles **youtu.be/Pn4vffdoCo8**

The Ogden Trust

making physics matter

The Ogden Trust aims to increase the uptake of physics post-16 by supporting physics education and engagement for all young people (4-18), particularly those in under-represented groups.

Visit **ogdentrust.com**

SKPT SUBJECT KNOWLEDGE FOR PHYSICS TEACHING ELECTRICITY

SKPT SUBJECT KNOWLEDGE FOR PHYSICS TEACHING WAVES

Tackling the 'dread' of teaching physics

The pivotal role of the teacher in stimulating an appreciation of physics in their students and encouraging a desire for further study cannot be underestimated. The fact that many non-specialist teachers who have responsibility for teaching the subject approach it with what James de Winter calls 'dread' signals a real issue for physics education. Teaching out of specialism can be daunting but many teachers have found that subject knowledge enhancement courses can help to improve their confidence and enjoyment of teaching physics.

The Ogden Trust now delivers the Subject Knowledge for Physics Teaching (SKPT) programme, a blended learning experience designed for teachers who have responsibility for teaching physics at KS3 or KS4 in the English state sector, without a physics specialism. The course is designed to develop teachers' subject knowledge and consider effective pedagogical approaches.

The SKPT programme comprises six modules which can be taken individually or built up as a professional portfolio. Each module takes up to 20 hours to complete and is led by subject specialists. The course includes face-to-face practical sessions and mathematical problem solving; conceptual challenges and pedagogical reflections are built into the online learning.

A recent SKPT participant told us: "I started out absolutely scared out of my wits to teach physics and I have to say you have converted me. I really love the subject now and am proud to say that I am a physics teacher."

The **waves** and **electricity** modules will be starting in October, then **matter & space** and **energy** in February 2023. For more information, booking or enquiries, visit **ogdentrust.com/SKPT** or email **skpt@ogdentrust.com**

STEM LEARNING

We aim to provide a world-leading science education for every young person across England, regardless of background or circumstance, achieved through career-long, science-specific CPD to teachers of all key stages

Visit **stem.org.uk**

Can maths and physics co-exist harmoniously?

Mathematics is the language of physics, to paraphrase Galileo Galilei and it's certainly a tool used in physics, so what's the problem?

Some students find transferring skills learned between the isolated school subjects of physics and maths challenging. But if teachers of both subjects are more aware of each other's curriculum, students can be better supported in linking these subjects.

STEM Learning and its partners continue to strive to break down the barriers that create these challenges. Huge benefits can be achieved by linking the two subjects but one of the challenges in a school is finding the time for this collaboration.

We offer residential CPD at the National STEM Learning Centre in York (bursary funding available):

Maths for A-level physics: **stem.org.uk/NY294**

Developing shared approaches for maths in science and science in maths: **stem.org.uk/my219**

The Stimulating Physics Network (SPN) offers fully DfE-funded support for secondary schools in England. An expert physics coach provides bespoke support and CPD for all teachers of physics in a local cluster of partner schools and can facilitate meaningful cooperation between different departments in the school, including the maths department.

The SPN coach helps address the specific challenges in each school, ensuring the maximum benefit to the school for the time invested by the teachers and department leaders.

Find out more about joining or becoming a partner school at **stem.org.uk/stimulating-physics-network**

Funding opportunity: what will you investigate?

Your school could receive up to £3,000 to run an investigative STEM project in partnership with a STEM professional from academia or industry through the Royal Society's Partnership Grants scheme. The scheme is available to primary and secondary level schools across the UK and the 2022 application round is currently open, closing at the end of November. Apply now to run a physics-based project in your school. Support is available from the Society's Schools Engagement team, including free online training sessions about the scheme and application process.

Find out more and apply via their website **royalsociety.org/partnership** or contact **education@royalsociety.org**

Using citizen science to bridge the gap between school science and STEM research and careers

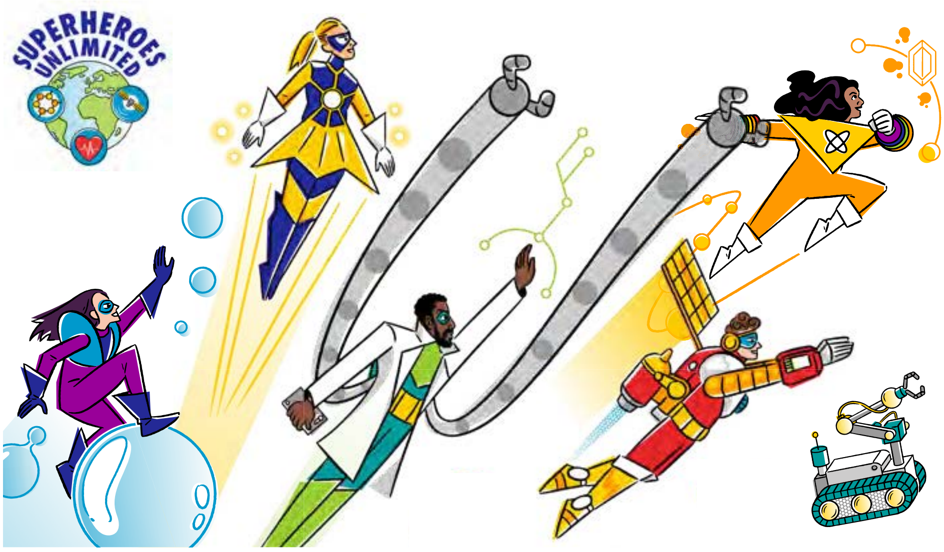
The Oxford University Physics Department and the Zooniverse team are running an exciting new collaboration to bring your pupils and researchers together using citizen science.

Get involved:

- Direct delivery of workshops in your school
- CPD to support you to use Zooniverse and related activities
- Online activities with I'm A Scientist Get me Out of Here (launching in BSW 2023)

Contact us at: **zooniverseinschools@physics.ox.ac.uk**
Follow us at: **www.physics.ox.ac.uk/engage/schools/secondary-schools/zooniverse-schools**

Sign up for updates:



What do superheroes and physicists have in common? Introduce your students to Laser Lady, Molecular Manipulator and UltraSonic to find out

Meet our superheroes

Introduce your students to some real-life superheroes, physicists whose work is tackling the challenges we face as a society, a species and residents of planet Earth! These resources were developed as part of the IOP's summer exhibition for families, but our teacher pack means they are great for showing the marvel-ous careers available if they study physics.

more...

iop.org/explore-physics/superheroes-unlimited

IOP Education becomes Learning & Skills

With the recent relaunch of the IOP's Education department as Learning & Skills, we are putting a greater emphasis on partnerships at the core of how we work with the aim of expanding our combined reach across the UK and Ireland.

In practical terms, we are working witha range of partners who provide excellent physics CPD including STEM Learning, the Ogden Trust, ASE and Physics Partners. We are tackling diversity in physics through the Limit Less campaign and now have a dedicated focus on the important role of technical pathways feeding into physics-rich occupations.

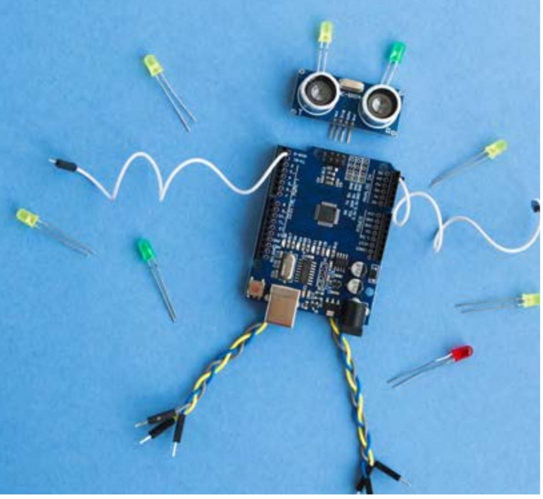
In addition, we continue to work on curriculum, in-field physics teacher recruitment and retention, pedagogy and professional practice and inclusion. Ultimately, our aim is to ensure that all students have a world class experience of physics through excellent teaching of a great curriculum.

Get in touch with us at **teachingcommunity@iop.org**

School Grants Scheme – what could you do with £600?

Grants of up to £600 for projects, events and activities that promote a greater interest in physics and engineering in young people. Funded by the Institute of Physics, Institution of Engineering & Technology and the Science & Technology Facilities Council.

iop.org/schoolgrants



Physics for everyone

It was wonderful to see nearly 200 colleagues coming together in June at the University of Birmingham. This was a new venture, bringing together teachers, technicians, CPD leaders, teacher trainers, education researchers and more to discuss classroom trends, new ideas and how to encourage students from every background to study physics. We were delighted to host entire strands around physics education research, careers and inclusion, areas in which we will be doing more work in the future. Presentations from the event are available at **bit.ly/TPbham22** (you'll need to sign in to TalkPhysics and then join the group to access the resources).

Look out for future in-person events at **talkphysics.org/events**

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