

Policy

Physics glossary makes its debut

We have been working with the National Physical Laboratory (NPL) to jointly develop a glossary of physical quantities encountered in post-GCSE school physics for use by 16- to 19-year-old students, their teachers and awarding bodies.

The aim, rather than writing a textbook, is to provide an authoritative voice that can help give confidence to all those involved in physics education at this stage, in the correct and consistent use of quantities, from conductivity and current to wavelength and work. A hugely challenging and endlessly fascinating project, the physics glossary is a work in progress after more than three years.

The project passed a significant milestone in November, when, with financial support from the European Physical Society (EPS), the current versions of 33 of the definitions were presented to physics educators from around Europe in a seminar at EPS headquarters in Mulhouse, France. The aim of this event was to explore the potential benefits afforded by this resource, or a similar one, in other European countries. The feedback received was highly encouraging.

Ian Bearden, vice-chair of the EPS Physics Education Division said: "The idea is beautiful and the execution is very good. I am grateful for the opportunity to read this." Aleš Mohorič, of the Slovenian Physical Society added: "In Slovenia we have these kinds of [physics] conversations, but we never produce anything like this."

Next steps include gauging interest among the EPS's individual member societies in a possible franchising of the glossary in different countries, determining the mechanisms for including European voices in its working group, and, perhaps most crucially, presenting the work to A-level awarding bodies and textbook writers here in the UK.

Beside all this, of course, the run-of-the-mill work of debating, reviewing and refining definitions continues: with 35 more quantities to define for 16 to 19, plans are afoot to develop a similar glossary for GCSE-level and beyond!

Each entry lists the quantity in terms of:

- description
- discussion
- SI unit
- expressed in SI base units
- mathematical expressions
- related entries
- in context

For more information: if you are a physics teacher and interested in becoming involved as an external reviewer, please do contact the physics glossary co-ordinator for more details at daniel.heanes@iop.org.

Do lions outnumber primary physics teachers in Wales?



There are "more lions in Wales than primary school teachers with a physics degree". This is what IOP chief executive Professor Paul Hardaker told an event at the Welsh Assembly building in January. He said that it was imperative to step up teacher recruitment and retention and to

encourage more young people, particularly girls, to study physics in order to expand the STEM-skilled workforce in Wales. The Minister for Welsh Language and Lifelong Learning Eluned Morgan praised the Institute's work in taking initiatives out to young people.

The latest physics education news, resources and classroom ideas – from the IOP education team

In this issue

With this issue of *Classroom Physics* you will receive:

- Improving Gender Balance postcards
- RAF flyer
- Tomorrow's Engineers careers leaflet



Science Teacher SOS!

If you are thinking of leaving teaching, this resource might just help you to think again.

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New GCSE grading

Sarah Old from Ofqual writes about what to expect from the new grading system this summer.

6

IOP RESOURCES FOR TEACHERS

We have a comprehensive set of resources that cover all syllabuses at secondary level. Plus you'll find lots more ideas and activities at iop.org/teachers

Supporting Physics Teachers

for those teaching up to age 16
supportingphysicsteaching.net



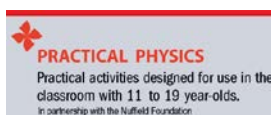
Teaching Advanced Physics

for those teaching ages 16+
tap.iop.org



Practical Physics

for those teaching ages 11–19
practicalphysics.org



Qubit

newsletter for ages 16–19
iop.org/16-19



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IOP Institute of Physics
Education Supporting Teachers

Teacher recruitment

Where are next year's trainee teachers?

The start to this year's recruitment cycle for physics teacher training has been slower than previous years: by mid-January, 30% fewer applications were registered. However, it is early days and we are quietly optimistic that this will turn around.

For schools who are recruiting a trainee teacher, our Initial Teacher Education marketing team can offer some suggestions for how to reach potential applicants and promoting the benefits of teaching.

For further information: visit bit.ly/recruitphysics for our support for schools in recruiting trainee teachers or iop.org/teach for our support for potential applicants.

£2k boost for teachers training with IOP

If you have a physics teacher trainee starting in September 2018, please encourage them to apply for the IOP Teacher Training Scholarship at iop.org/scholarships.

Benefits include:

- £28,000 funding (a £2,000 uplift from the bursary)
- being part of our Scholar community
- celebration event to welcome them to the programme, providing practical tips for their training year and the opportunity to meet experienced teachers and a recent scholar
- three further workshops during the year, designed specifically for trainees, led by our experienced training coaches
- IOP membership including subscriptions to *Classroom Physics* and *Physics World* magazines, as well as being part of a wider community of physicists.



One of our current IOP Scholars, Ben said: "The events I'm invited to are great opportunities to network. Being able to talk to peers allows you to feel like you're part of a community who are going through the same highs and lows as you, and it's a great way to gain ideas for lessons. They also give you opportunities to speak to experienced physics teachers from all over the country."

New ways to engage #teachphysics

Engaging with prospective teachers is always a challenge. There are tried and tested methods that bring results: university events, promotional leaflets and school experience. But are we only preaching to the choir?

Given the current teacher shortage, we need to expand our horizons and engage with those on the periphery who have always fancied teaching but haven't taken action. So, outside the usual channels, where do we look?

In January, we ran our first live Twitter Q&A with one of our current Scholars, Katie Hassell (catch up with it using #teachphysics). We had interesting questions, likes and retweets from a host of unexpected places in the Twitterverse, showcasing our message to a wider audience than previously.

It also enabled us to show off an inspirational teacher who is positive about being in the classroom. While there are negative media stories around teaching, we can present another side to the story.

Ways to promote your training place:

- Run your own Twitter Q&A using the hashtag #teachphysics
- Sign up to give prospective teachers observational experience at iop.org/sep
- Tell prospective teachers about the funding and support available via IOP Scholarships
- Email anyone who has enquired about training to tell them more about your course
- Create a promotional video of your teachers: include what they enjoy most about teaching and the great experience your trainees have
- Attend a recruitment fair, or hold your own, to meet prospective teachers face-to-face
- Use any social media channels available to you.

Teacher CPD

Capital Physics creates physics capital

The final evaluation of our Capital Physics project has shown that it has boosted physics A-level retention and attainment, especially for girls.

The programme of professional development for Key Stage 5 teachers and technicians has been running in more than 80 state-maintained London schools since summer 2014. Exam-results data show:

- Student retention: the mean percentage of female AS-level students at Capital Physics schools retaining physics to A-level increased between 2014–15 and 2015–16 by 14%, compared to an increase of 7% for a group of London schools with comparable 2014 performance.
- Student attainment (male and female): between 2014 and 2016, Capital Physics



London teachers get to grips with practical work at an electronics workshop.

Join IOP programmes in UK & England

Find IOP support in the UK and Ireland

- The Physics Teacher Network offers CPD, support and advice to all teachers of physics across UK and Ireland, iop.org/network.
- The Stimulating Physics Network supports Link and Lead Schools to provide CPD workshops and networking opportunities to groups of local schools in England, stimulatingphysics.org/link-lead-schools.
- Future Physics Leaders works with Partner and Lead Schools in social mobility coldspots to raise standards in physics teaching across the local area, bit.ly/FuturePhysicsLeaders.

Partner Schools showed a 14% increase in their mean number of UCAS points per entry in AS-level physics. This compares to a 6% drop in the comparison group, possibly due to the revised specifications and practical assessments.

Feedback from teachers has shown the qualitative value of this CPD:

- “I am the only physics teacher in the school, so getting to meet other physics teachers is invaluable. You can talk about the syllabus and practicals, whereas in normal circumstances you would not have that opportunity.”
 - “Nowadays we have the Internet, and you can type in something, but that doesn’t solve your problems like having a coach does.”
- Capital Physics provides termly

meetings in six hubs across London where teachers, IOP coaches and Ogden Teacher Fellows exchange teaching ideas and demonstrations. The coaches visit schools and lead bespoke sessions with smaller groups of teachers and technicians. There is also an annual conference for all participants.

The funded project finishes this academic year, but we intend to maintain these supportive communities and share their resources across other IOP networks.

For more information: visit iop.org/capitalphysics. A-level physics teachers in London schools can get involved by contacting the project manager: robert.birke@iop.org.

Teacher support

Whatever happened to a decent work–life balance?

Teacher retention has made the headlines recently, but it has always been an issue. Although no subjects are immune, science is particularly affected. Research has shown that the odds of science teachers leaving their school within five years are 26% higher than for similar non-science teachers.

There can be a number of reasons why teachers may consider changing or leaving their job. Common reasons include stress and workload issues. We have reached a point where there are unprecedented levels of workload commitment for teachers. Many are left feeling isolated and think that leaving the profession is their only option.

The Association for Science Education has created a short, non-judgemental document called the “Science Teacher SOS”, which helps teachers explore their reasons for wanting to leave and offers advice at different levels depending on the role within the school.

Talk to a physics teacher who understands



Gary Williams, manager of IOP’s Physics Teacher Network, said, “As someone teaching physics you are part of a community. Teaching is tough, but the support offered by our community is fantastic. If teaching seems to be getting too tough,

think about whether you really want to leave or whether it would be better to change school. The social media and e-mail lists where we share ideas, the twilight sessions, the regional day meetings, not just from IOP but from other organisations and schools, all make for a supportive community that is second to none. Talk to your peers, ask for help, enjoy physics.” Contact your local Physics Network Co-ordinator at iop.org/network.

Shaun Reason, ASE chief executive, said, “If you, a friend or a colleague feel that you are at the point where you are considering leaving teaching altogether, we want you to know that we understand and are here to provide support. We have created this booklet to help you consider your position; and will support you in whatever decision you make.”



For more information: download the Science Teacher SOS guide at ase.org.uk/sos. The ASE has set up an emergency email address at sos@ase.org.uk.

Technicians

Celebrate your school science technicians

#TECHOGNITION

5-9 March 2018

#TECHOGNITION week is “a national celebration of School Science Technicians, recognising the importance of this essential role in science education”.

The organisers hope the campaign will publicly showcase the diversity of the role, and the expertise and essential knowledge technicians bring to science education.

Technicians will be encouraged to take part in #TECHOGNITION by uploading photos of themselves and technician colleagues undertaking any of the weird or wonderful, mundane or exciting, routine or unique tasks they are required to do. Photos will be entered into a daily prize draw.

#TECHOGNITION is a partnership between school technicians’ website preproom.org and public service union UNISON. The campaign follows preproom’s 2016 UK School Science Technician Survey. More than 1300 technicians responded to the survey, which concluded that the majority of technicians felt that school leaders and the government do not understand the role of the school science technician.

For more information: visit techognition.org.

Resources

Schools competition takes off



Year 8 boys test out their gliders at the launch event.

RAF100, our joint project with the Historical Association (HA) celebrating the centenary of the RAF, was officially launched in January this year.

The project is presented through a website that includes downloadable activities for STEM clubs and videos to help students explore how technological development has been entwined with the history of the RAF over the last 100 years. Students are invited to enter a competition that asks them to find out more about a local RAF base and present an idea of how technology from, or for, the RAF may develop in the future.

Rebecca Sullivan, the HA’s chief executive, said: “Bringing the two disciplines of history



and physics together to help young people explore the role and impact human actions have had in creating the modern world has been really exciting.”

For more information: visit raf100schools.org.uk.

CPD

Free electronics workshop

The ongoing shortage of electronic engineering graduates in the UK has prompted the University of Southampton to invite A-level physics teachers to spend two days in its labs this summer (17–18 July).

The aim is to boost teachers’ confidence in teaching electronics at A-level. Free to attend, teachers will stay overnight for two days of workshops. They will focus on an interactive “music mixer” teaching tool developed at the university. Students can use this to experiment with electronic components. The mixer combines two audio signals, for example music from their mobile phones, encouraging students to control the volume by experimenting with different electronic components. Its design exposes all components and demystifies electronics for the students.

A teacher who attended last year’s course fed back: “The kit really allowed

me to focus in on the lesson as it removes the set up...The students were engaged as they have never experienced this type of electronics before. The results they get are fantastic.”

Dr Alex Weddell, Senior Admissions Tutor for Electronics at Southampton and workshop leader, said: “This tool was really well received by the teachers last year. We have a vibrant and growing electronics sector in the UK. We are looking forward to seeing this new hands-on tool provide a visual and practical way for teachers to deliver electronics concepts within the physics curriculum and inspire more pupils to take up the subject.”

The programme is being delivered in a partnership between the Department of Electronics and Computer Science at the University of Southampton and the UK Electronics Skills Foundation.



For more information: or to book a free place, visit www.workshop.soton.ac.uk. More about the UKESF’s resources for schools at ukesf.org/schools.

Improving gender balance IOP's got talent

We were delighted to see our gender balance work recognised in November with a Talent Award from Women into Science and Engineering (WISE).

Commenting on the award winners, WISE said: "The Institute of Physics was honoured for their guidance on tackling gender stereotypes in schools, which pilot schools have used to more than treble the number of girls taking AS-level physics over two years."

Jessica Rowson was presented with the award on behalf of the Institute by Princess Anne. Jessica, who has been leading the Improving Gender Balance (IGB) project, said: "It's fabulous to see our work recognised in this manner. We hope that this will raise the profile of what we have achieved and give confidence to people working in education in the whole-school approach to improving gender balance."

Going forward, the IGB team continues to work with teachers across the country, supporting them to address stereotyping in the school environment. Following a successful trial of a gender-equality mark for



Her Royal Highness The Princess Royal presented the Talent Award to the IOP's Jessica Rowson.

schools, they are also developing a national scheme to recognise good gender-equality practice in education.

For more information: if you would like to get support in your school or if you are part of an organisation that would like to support the development of the gender-equality mark, contact our new gender balance manager: beth.bramley@iop.org.

'Boys and girls are just different'

Heather Earnshaw, our improving gender balance project manager in Scotland, hears assertions like this a lot.

Her team have produced a set of postcards aimed at changing mindsets by provoking discussion amongst teachers and senior managers in schools.

"We hope these postcards will provide a quick and easy way to highlight and counter some of the persisting myths and misconceptions around gender in education. All the statements are things we hear often in schools and early learning centres. The responses on the back are all a distillation of the relevant research further described in other IOP publications.

"The IGB Scotland project aims to establish school interventions to effect long-term cultural change, with a particular focus on challenging gender stereotypes in STEM subjects. The focus of the project is helping teachers and senior managers within primary and secondary schools and early learning centres understand gender stereotyping and develop approaches to tackle it. The interventions are evidence-based and are carried out by the schools, facilitated and supported by the IGB Scotland project officers."

A set of postcards is included with this issue. They are also available to download as both postcards and posters from the



IOP website at iop.org/genderresources. Please do use them to raise awareness of gender-related issues in your school, challenge some commonly held assumptions and point colleagues to the wealth of resources the IOP has produced to support schools in tackling gender imbalances as a whole-school issue.

For more information: visit iop.org/genderbalance.



Teaching electromagnetism

Truro College, TR1 3XX

25 April 2018

Join us for an early evening of electromagnetism for KS3 and KS4. Electromagnetism can be a confusing topic for learners. This workshop will focus on building confidence with the abstract ideas and overcoming the practical challenges. We will discuss and demonstrate helpful ways of teaching the effects and uses, including the motor effect. Register at bit.ly/TeachEM.

The Institute of Physics Yorkshire Day

Our first regional day of 2018 saw 62 delegates make their way to Leeds University's School of Physics and Astronomy for a full day of fully funded CPD.

Professor Helen Gleeson, Cavendish Professor at the University of Leeds, was on hand to give the participants a warm welcome at the beginning of the day, gearing them up for a series of topics such as energy in the KS4 curriculum, waves, teaching the "measurement problem" of quantum mechanics, unconscious bias and much more. A tour of the research facility of the school of physics and astronomy was available too, giving those that signed up a chance to see the facilities on hand and learn a bit more about the work that is being done.

As always, there was a strong presence on Twitter. Devinder Gill, one of our physics network coordinators, followed the action on the day. You can see what happened by following him @Gill_Physics.

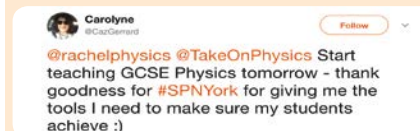
Events across the regions

- Peter Titkin ran an energy CPD day at Brooke Weston School in Corby in December.
- Dan Cottle hosted an electricity make and take at King Edward VI Five Ways School in Birmingham in December.
- Science Ambassador training days took place in Manchester, Northampton and London. View and sign up for our upcoming Science Ambassador days at stimulatingphysics.org/sas.

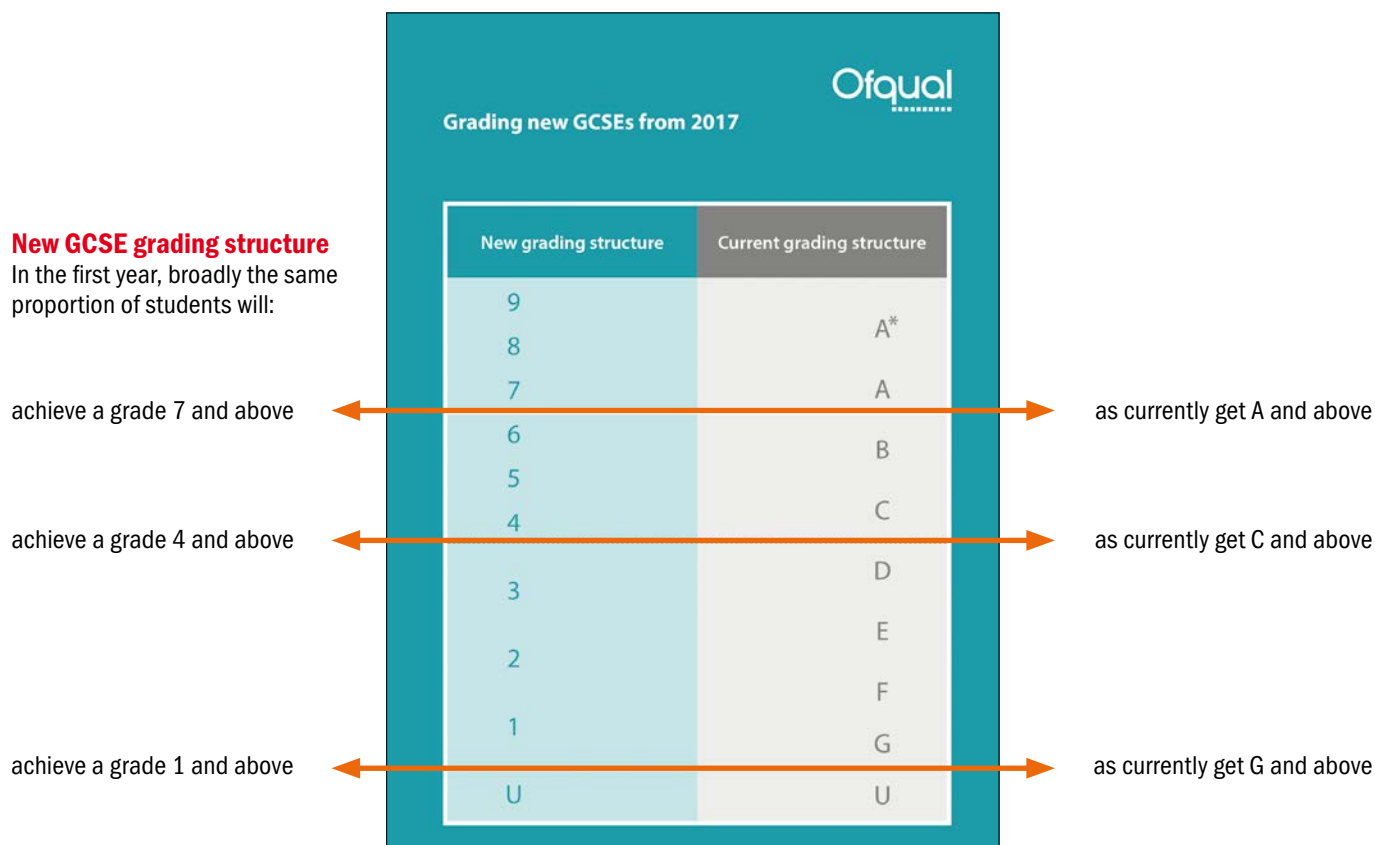
Community



Follow us @TakeOnPhysics for advice, ideas and events for teachers of physics.



Ofqual note on the grading for the new GCSEs



Sarah Old, Senior Manager, Standards for Design, Development and Evaluation of General Qualifications, Ofqual, writes.

New GCSEs in physics, chemistry, biology and combined science (a double-award qualification) will be awarded for the first time this summer.

All of the reformed GCSEs are based on new, more challenging, subject content and assessment requirements, and will be graded from 9 to 1 (9–9 to 1–1 for combined science), with 9 being the highest grade. The new grades signal the changes to GCSEs, with more grades at the top end to differentiate better between higher-ability students.

As many of you will know, physics and combined science GCSEs have some key changes to their assessment, including:

- all examinations now being taken at the end of the course and an allocation of the marks in the examination papers to the assessment of mathematical skills;
- the way that practical work is assessed has changed – students have to be provided with the opportunity to complete at least

eight practical activities for each of the separate sciences, 16 for combined science;

- practical skills are now assessed indirectly in the written examinations;

- foundation and higher tiers are permitted in the reformed science GCSEs, with a requirement that 20% of the questions are in common between the two tiers.

Exam boards will use statistical predictions as the basis for setting standards in the new GCSEs, including those in the science subjects, this summer. The use of statistical predictions will ensure that those student cohorts that are first to sit these new qualifications will not be disadvantaged compared to those who took the subject previously.

If the ability of the national cohort is similar to last year, the proportion of students achieving grade 7 and above will be broadly similar to the proportion of students achieving grade A and above in 2017, and the proportion of students achieving grade 4 and above will be broadly similar to the proportion that achieved grade C. Exam boards will be relying heavily on the statistical evidence to ensure that this

year’s cohort is not unfairly disadvantaged, but also using senior examiners to check the grade boundaries that the statistics are pointing to.

Grade 9 is not the same as A*. It is a new grade, designed to recognise the very highest performing students and therefore there will be fewer grade 9s awarded than A*s previously. Grade 9 is calculated arithmetically using a formula. Overall, across all GCSE subjects, the proportion of students achieving a grade 9 will be around 20% of those achieving a grade 7. However, the numbers will vary across subjects, and in the separate sciences, including physics, because of the likely different profile of the cohort taking these subjects. The percentage of grade 9s awarded is also likely to be higher.

The Ofqual Blog (ofqual.blog.gov.uk) covers a range of relevant topics, and we plan to blog with further information about the new GCSE science qualifications this spring.

For more information: to learn more contact Sarah by email at sarah.old@ofqual.gov.uk.

Stories about physics

Counting the cost

More stories in our series delving into the history of science and contemporary research, compiled by Richard Brock.

Drumming up the energy

There are a number of ways to measure the energy transferred when a person engages in different activities. In one approach, a participant wears an insulated, water-cooled suit and the energy transferred is calculated from the flow rate of water and its incoming and outgoing temperature. Such techniques have been used to collect data on highly specific activities (see table). For example, a recent paper reported a metabolic cost of around 26 kJ per hour per kg of body mass for drummers playing “metal standards” including Metallica’s *Fight Fire with Fire* and Slayer’s *Raining Blood*.

Joule’s eyebrows

James Joule’s later investigations indelibly linked his name with the concept of energy, but some of his early “experiments” are intriguing for different reasons. As a boy, Joule wanted to study how sound echoed from mountains in the Lake District. After firing his father’s cavalry pistol with a triple load of powder, the recoil blew the gun into a lake. Later misadventures with firearms cost Joule his eyebrows. Injuries from his experiments weren’t limited to his own body – having acquired a Leyden jar,



Photo by Jameson Murphy on Unsplash

The metabolic costs of heavy-metal drumming are around 26 kJ per hour per kg of body mass.

Activity	Energy cost (kJ per hour per kg of body mass)
Studying including reading and/or writing (sitting)	7.5
Shopping (non-grocery shopping, walking)	9
Getting ready for bed, in general (standing)	10
Police, making an arrest (standing)	33

the young scientist delivered shocks to a servant girl, increasing the voltage until his subject lost consciousness.

Why energy calculations matter

When planning his Antarctic expedition, Robert Falcon Scott used data describing the energy changes of men working in extreme conditions, collected on a previous expedition, but failed to consider that the trial had taken place at sea level. The raised elevation of his expedition caused his men to transfer more energy

than expected due to increased rates of respiration at altitude. Scott had planned his rations on the assumption that his men would require 19 kJ per day. In reality, they needed 29 kJ. The deficit would have led to each man losing 1.5 kg of body mass per week. It is estimated that Scott had lost around 40% of his body mass by the time of his death.

For more information: join the discussion at talkphysics.org/groups/stories-about-physics.

Applying physics education research to the classroom

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.

Concept inventories

Concept inventories are research-based assessments that aim to probe conceptual understanding. They usually consist of multiple-choice questions, which have been developed through rigorous scrutiny, much more than is commonly used for questions in textbooks or exams. They are typically used in research as pre- and post-tests when a particular approach or teaching strategy is being evaluated. As they are intended to be used as research instruments, they need to be used

cautiously and won’t be able to replace “normal” class questions. However, they provide a rich resource for physics education, particularly for teachers who are looking for ways to try to measure the impact of an intervention. They can also provide exemplars of well targeted questions to probe understanding.

Credentials

The most well known concept inventory, covering Newtonian mechanics, is the Force Concept Inventory (FCI), which has been taken by over 50,000 students in the US as part of many research projects (Von Korff *et al.* 2016). Madsen, McKagan and Sayre (2017) have written a useful catalogue of different concept inventories in physics and their degree of research validation.

More information

There are more than 60 research-based assessments across all topics in physics available through PhysPort at physport.org/assessments (registration required). Some are aimed at US undergraduates, but many are suitable for secondary-school students.

A paper, *Best Practices for Administering Concept Inventories*, available at arxiv.org/abs/1404.6500 gives details about the best ways to use and administer the tools.

If you would like to join other physics teachers interested in engaging with the latest research, discussing classroom applications, attending seminars and getting involved with research, email us at PER@IOP.org or join the Physics Education Research (PER) group on Talk Physics at talkphysics.org/groups/physics-education-research-per.

Ellen Philips, assistant editor of *Classroom Physics*, picks out stories from our magazine for the global physics community. If you are unable to login, email custserv@iop.org, explaining you are an IOP affiliated school.

When cold warms faster than hot

In 1963, a Tanzanian school student observed that his homemade ice cream froze faster than his classmates, if he didn't cool the boiled milk before placing it in the freezer. Despite his teacher initially ridiculing his observation, when a physicist, Denis Osborne from University College Dar es Salaam visited his school, Erasto Mpemba posed the same question. Osborne promised to try the experiment upon his return to the university. Much to his surprise, the experiment worked and years later they co-authored a paper on the Mpemba effect – the notion that hot water freezes faster than cold. In this article, author Jennifer Ouellette



describes what could be a new theoretical understanding for the so-called Mpemba effect – and why it predicts that cold water could heat up faster than warm water.

- In the December 2017 issue: bit.ly/PhysicsWorldCold.

What next for Fukushima?

On the afternoon of 11 March 2011, a 9.1 magnitude earthquake occurred roughly 70 km off the east coast of Japan. The fourth most powerful earthquake of modern times, it created a 15 m tsunami that hit the Fukushima Daiichi nuclear-power plant about an hour later. Almost seven years later, authors Bruce Drinkwater and Rob Malkin document their visit to the disaster site as part of a UK–Japan project working to create new technology for exploring the hostile environment within the damaged reactors.

- In the January 2018 issue: bit.ly/PhysicsWorldFukushima.

Physics in the dark

Every age has its great teachers, and in the early 18th century, one of them was Nicholas Saunderson. From 1711 until his death in 1739, Saunderson was the

Lucasian Chair of Mathematics at the University of Cambridge – a post held just a few years previously by Isaac Newton. He would lecture to packed halls for at least eight hours and was said to have a tremendous feel for his subject. Literally, as it turns out he was blind.

Author Jon Cartwright asks: “But just how easy is it for the sightless?” as he highlights the modern technologies and people working to make physics fully accessible to the blind.

- In the January 2018 issue: bit.ly/PhysicsWorldDark.

Marvin and Milo

Cartesian ketchup sachet diver

Marvin and Milo are the Institute's resident cat and dog experimenters. Download other Marvin and Milo experiments and STEM club ideas at iop.org/stemclubs.

DO TRY THIS AT HOME
#29
Featuring: Marvin and Milo

What you need: • 2 litre plastic bottle • Blue Tac • a bowl of water • a ketchup sachet

Today we are going deep sea diving with this ketchup sachet.

Put the lid on tightly, squeeze the bottle hard and watch your diver dive.

Squeezing the bottle compresses the air bubbles inside the sachet. This increases the overall density of the sachet. The sachet becomes denser than water and so it sinks. Can you explain what happens when you stop squeezing?

Put the ketchup sachet into a bowl of water to see if it floats upright – if not then add a little Blue Tac to its bottom.

Fill a 2 litre bottle with water right to the very top.

Push your ketchup diver through the neck.

www.physics.org keywords: density

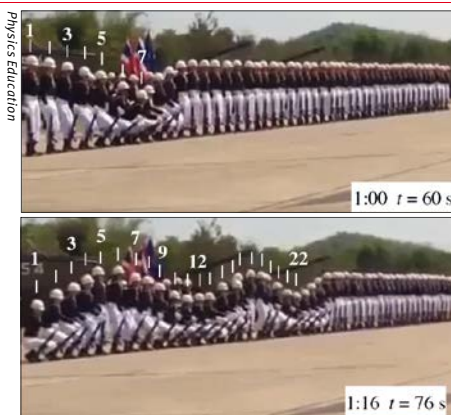
Vic Le Billion

Physics *education*

Gary Williams, editor of this IOP international physics teaching journal, shares some articles. If you have trouble following the links, email affiliation@iop.org for a reminder of your login details.

Understanding human waves

This paper analyses the wave in a viral video when a group of guards in the Thai Army march to the tune of "The Final Countdown" before jumping and crouching to create a rippling wave effect along their ranks. It's fun to watch and allows you to discuss all aspects of waves. Amplitude, period and frequency, wavelength and propagation speed can be measured. Distances reached by the wave at different times can be plotted and linearly fitted to yield the propagation speed as a result. Types of waves and the fact that there is no net movement of matter can also be covered. There's probably at



least a double lesson here.

- By Chantal Ferrer-Roca, Director of the Department of Applied Physics at the University of Valencia, Spain, in the January 2018 issue: bit.ly/PEdwave.

Avoid formulitis

This vintage paper describes two ways in which a formula can be used in physics: as a law and as a model. The main argument is that there is too much emphasis on the law aspect. Students manipulate equations without thinking about the meaning of what they do because it's quick. A formula derived as a model requires some thinking about it. It also needs to be compared to the data, often from experiment. This concise paper raises important points that I hadn't considered before.

- By Orren Tsuma, Institute of Education, University of Lagos, Nigeria, in the November 1983 issue: bit.ly/PEdformula

Super-curricular activities

Getting suitable reading material in front of students isn't always easy. Ken Zetie's idea

is to provide a large, searchable database of reading and other material such as podcasts rather than simply a static reading list. He encourages students to visualise and plot their trajectory toward a specific goal using a graph, creating their own list depending on their

interests and current level of understanding. Ken's spreadsheet listing resources is included as a download then you can update it and tailor it to your students.

- By Ken Zetie, St Paul's School, London in the March 2018 issue: bit.ly/PEdreading.

talkphysics

Caroline Davis, *Classroom Physics* editor, chooses some edited highlights from our online discussion forum for teachers of physics, technicians and teacher supporters. Log in or register to join these discussions at talkphysics.org.

Under pressure

Alison is teaching KS3 physics for the first time and was asked: "What is under greater pressure: a balloon filled with water or a balloon filled with air (balloons of equal size)? Will a balloon filled with water reach the same maximum size as a balloon filled with air (before it bursts)?" Nick, a lab technician and a TalkPhysics regular, suggests: "Try it out. I think you will find they behave very differently, for two reasons: gravity and the difference between liquids and gases."

- Follow the discussion in the Teaching Physics 11–14 group at bit.ly/TPballoon.



Misconceptions in colour and light

Trainee teacher Ben is writing an assignment that includes common misconceptions in colour (reflecting coloured light, filters and how we see colour). He asks for others to share their

thoughts. Meanwhile, physics teacher Physnova was wondering how to respond to his year-10 student who asked: "If light has no mass how does it get reflected?" The results were some fascinating posts and links from fellow *TalkPhysics* users.

- Follow the discussions in the News and Comments group at bit.ly/TPlightben and bit.ly/TPlightphysnova.

Investigating Terminal Velocity

Len is trialling the 'Investigating Terminal Velocity' practical in the OCR A-level syllabus. "I am not achieving terminal velocity. I am using glycerol in a burette. I find syrup is too viscous. I would be interested to hear from anybody who has got good results. Is there a better liquid I could use? Is there a better vessel I could use?" Len wasn't the only one struggling. Nick commented: "We gave up on it. I think the reason we could not get it to work was boundary effects where the fluid has to get past the falling ball. We could not get a combination that worked." Other *TalkPhysics* users shared their solutions: Jorge used small steel balls taken from a necklace falling through liquid soap in a graduated cylinder. Phil said cupcake cases dropped from a couple of metres height works quite well.

- Follow the discussion in the News and Comment group at bit.ly/TPterminalV.

Events

EVENTS FOR TEACHERS

Physics of Sports and Athletics

Worcester University, WR2 6AJ

19 March

This workshop will explore physics principles linked to sports and athletics, inspired by the Olympics. It introduces classroom activities, practical ideas and resources suitable for teaching KS3 and KS4. Details and booking: bit.ly/PhysicsSports.

Modelling Basic Circuits

King Edward VI Five Ways School, B32 4BT

21 April

This day of physics teaching development is aimed at those teaching 11–14 circuits and looking to take things further. Ideal for those without a specialist background in physics, and NQTs, most teachers of physics will discover something useful to take away. Details and booking: bit.ly/ModellingElec.

Teaching electromagnetism

Truro College, TR1 3XX

25 April

This workshop will focus on building confidence with the abstract ideas and overcoming the practical challenges. We will discuss and demonstrate helpful ways of teaching the effects and uses of electromagnetism, including the motor effect. Details and booking: bit.ly/TeachingElectromagnetism.

Practical Physics Sessions

Exeter Mathematics School, EX4 3PU

3 May

Though a practical subject at heart, some of the practical activities can seem abstract to our students. In this session, Malcolm Simpson will discuss techniques to help plan and deliver interesting and effective laboratory work. Details and booking: bit.ly/PracticalPhysicsSession.

Rockets Make and Take

Tunbridge Wells Grammar School for Boys, TN 9XB

9 May

Make and take a launcher for paper “rocket” projectiles, allowing a dynamic approach to teaching motion, forces, projectiles and so on. Details and booking: bit.ly/RocketsPhysics.

A-level Physics CPD

Sir Christopher Hatton Academy, NN8 4RP

7 June

This A-level Physics CPD day will give you an opportunity to try out a range of practical strategies and demos. In addition to the two practical sessions, the day includes a maths for physics session in which you will learn how mechanics is treated in A-level



Find a local CPD event at talkphysics.org/events.

maths compared with A-level physics. Details and booking: teachingschool@hattonacademy.org.uk.

IOP North West Physics Teacher Conference

Daresbury Labs, WA4 4AD

28 June

The day will feature a lecture followed by three workshops and provide opportunities to swap resources and network. Details and booking: andrea.fesmer@talk21.com.

Making Materials Matter Science Teachers Conference

The Ironmongers Hall, EC2Y 8AA

13 July

A day conference providing opportunities to network with colleagues and learn more about the subject of materials science, where it fits into the current curricular and the importance of science enrichment opportunities. Details and booking: bit.ly/MaterialConference.

EVENTS FOR STUDENTS

Salters' Festivals of Chemistry

Students will experience exciting hands-on practical chemistry challenges, a chemical demonstration and all teams will receive prizes and certificates, while teachers have the opportunity for CPD and networking. Only £30 (£35) per school, travel expenses will be paid. Details and registration: festivalsofchemistry.co.uk.

IOP 3MW Grand Final

The Royal Institution, W1S 4BS

22 May

The IOP's 3 Minute Wonder science communication competition challenges researchers to explain their work in just three minutes. Join us to watch the finalists and vote on the winner. Details and booking: bit.ly/3MWcompetition.

DEADLINES

IOP School Grants

One-off grants of up to £600 for projects or events linked to teaching or promoting physics and engineering in UK schools and colleges for students aged 5–19 years. Deadlines for 2018: **1 June** and **1 November**. To download an application form and for more information, visit: iop.org/schoolgrants.

SAVE THE DATE

Rugby Meeting

Rugby School, CV22 5DW

7 June

Join us for a day of lectures and workshops at the largest meeting of the physics – teaching community in England. Details and booking: iop.org/rugby.



Salters' National Awards for Science Technicians

Closing date 4 May

In collaboration with CLEAPSS and SSERC, the Salters' National Awards for Science Technicians highlight the importance of Technician teams (although sole Technicians are also eligible!). The awards are open to all Science Technicians in schools and colleges for students up to the age of 18. For more information, visit: saltersinstitute.co.uk/awards/.



Determining density

Method

1. For each piece of modelling clay, measure its mass using the weighing scales. Write your result in the table below.
2. Obtain its volume by placing the modelling clay in the “Eureka” can and collecting the water it displaces in the measuring cylinder. (It is easiest to tie the clay onto a piece of string so you don't have to fish it out of the bottom of the can afterwards). Write your result in the table below (1 ml is equal to 1 cm³).

Table

Notes (material, dimensions)	Mass (g)	Volume (cm ³)

Analysis

1. Plot a graph of mass (y -axis) against volume (x -axis).
2. Draw a straight line of best fit through your data points.
3. Measure the gradient of your best-fit line. The gradient will give you an average value for the density of the material.

Evaluation

1. Are there any anomalies among your data points?
2. Do you expect your best-fit line to pass through the origin?

Determining density

Students commonly think that “dense” means “heavy”: they assume a more dense object always weighs more than a less dense object. This practical activity allows you to discuss the meaning of density and explore this misconception.

Equipment required per pair of students

- Ruler
- Digital balance (0–1 kg)
- Small blocks of different metals and non-metals (materials kits are available from most educational science equipment suppliers)
- About 200 g modelling clay/play-doh in various shapes and masses, up to say 70g
- Eureka can (see figure 2) and measuring cylinder

Optional teacher demonstration

- Cans of diet and full-sugar fizzy drinks
- Small objects that can be hidden in the modelling clay
- Large bowl or tank of water
- Fruit juices

The practical activity

Density cannot be measured directly so students measure two other quantities – mass and volume.

1. For the regular-shaped samples of metals and non-metals, volume can be calculated by measuring the dimensions of the blocks. Students then determine the mass and calculate density using the formula: $\text{density} = \text{mass}/\text{volume}$.
2. For the irregular-shaped objects made out of modelling clay, students need to measure the volume by filling a displacement or “Eureka” can. The volume of water displaced by the modelling clay into the measuring cylinder is equal to the volume of the object (see figures 1 and 2). Students can then calculate the density of modelling clay using the above formula.
3. A nice way to bring in graphical skills is to measure several modelling clay objects of different shapes and sizes. Students plot a graph of mass against volume to determine an average value for the density of modelling clay, using their skills to draw a line of best fit (see worksheet on p11).

Hidden challenge

Make this activity more challenging by hiding items of different densities in the modelling clay lumps – perhaps a ball bearing or a hollow core. When students plot the graph, they will obtain an anomalous point. Challenge them to offer an explanation.

Forensic challenge

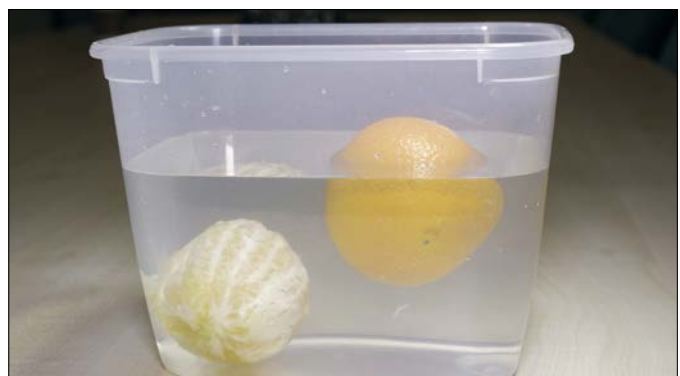
As an extension, provide mystery samples of a regularly shaped material (e.g. a painted block). Explain that the composition of unknown objects can be determined by working out their density, which could be crucial in, for example, a forensic crime scene investigation. Challenge students to identify the material by making mass and volume measurements.

Food challenges

- Demonstrate an orange’s life jacket. Without its peel, which is full of air pockets, the orange sinks (figure 3).



Figure 1 (above): Fill the Eureka can up to the spout hole. Use the measuring cylinder to capture any overflow and then empty the cylinder. Figure 2 (left): Lower the object into the Eureka can. Read off the measuring cylinder the amount of water displaced by the object and hence its volume (1 ml is equal to 1 cm³). Figure 3 (below): An orange with peel is less dense than water. But removing the skin makes it sink.



- Make layered mocktails with fruit juices containing different amounts of sugar: grape juice at the bottom, then orange juice, then pomegranate juice.
- There are lots of videos online showing diet drinks floating while their sugary counterparts sink. We couldn’t get it to work – can you?

Further information

More experiments for density can be found at practicalphysics.org/measuring-density. For more information about teaching density see bit.ly/SPT-Density.

This teaching tip was developed to accompany the Density thread on the Required GCSE Practicals from 2016 group on TalkPhysics at bit.ly/TPdensity. This group is for teachers getting to grips with the new practical requirements of the revised GCSE specifications, but will be of interest to anyone leading practical work at this level. Other threads include Hooke’s law, specific heat capacity and light: reflection and refraction.