

Classroomphysics

The newsletter for affiliated schools

December 2017 Issue 43

CPD

Physics boost for English cold spots

We are delighted to launch a new project with a focus on social mobility. Funded by the Department for Education, the Future Physics Leaders (FPL) project will work with 168 schools in areas of England that have been identified as social mobility “cold spots”.

If your department is in a school that is seeking to improve attainment, with a low Ofsted rating or a record of progression in physics that needs to be addressed, this project may be able to help. We can offer CPD for specialist and non-specialist teachers of physics, support with the recruitment and retention of NQTs, and will develop a group of teachers into subject leaders.

We are also looking for schools in these areas with a strong physics department that want to take on a leading role and support other local schools.

IOP head of education, Charles Tracy, said: “This project represents a much-needed opportunity to develop great teaching and leadership in schools that need stability and support. Many students – including those in priority areas – miss out on the opportunities that a good physics education provides because their schools are unable to recruit and retain specialist physics teachers.”

FPL will use a “hub and spoke” model similar to that of our long-running Stimulating Physics Network. Schools in our target areas (for more information, see end of article) will work in small groups called hubs, each made up of one Lead School and six Partner Schools.

Lead Schools will host CPD sessions for their hub and each will identify one physics teacher to join the group of future subject leaders. This group will be given intensive



The Future Physics Leaders project will improve the recruitment and retention of physics teachers in schools in areas identified as social mobility “cold spots”.

Sympathetic timetabling: the key to NQT recruitment and retention?

Research suggests that timetables where NQTs teach only physics lessons and teach more than one group in a year improve retention. This isn't a reduced teaching timetable, but such “sympathetic timetabling” can considerably reduce workload in an NQT's early years and we believe it can also make NQT positions more attractive to candidates. We would encourage all schools to adopt sympathetic timetabling, and so FPL schools will be offered support with recruiting NQTs on the condition that they agree to introduce this approach.

coaching sessions and work with IOP staff so that, by the end of the project, they will be able to coach other physics teachers in their area.

Partner Schools will be offered a comprehensive package of CPD. As well as sessions aimed at non-specialist teachers of physics, we will run regular workshops for specialist physics teachers, exploring topics including: physics pedagogy for high attainment; engaging low socio-economic status and female pupils in physics; physics leadership in schools and developing a culture of physics.

FPL is one of eight successful projects being funded by the government's £75 million Teaching and Leadership Innovation Fund (TLIF).

For more information: and to find out if you are in one of the FPL target areas, visit bit.ly/FuturePhysicsLeaders. More information on TLIF at gov.uk/guidance/teaching-and-leadership-innovation-fund.

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

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Helping young people see the benefits of physics and provide their own source of employment.



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Examples that can be used for practice and as a basis for discussion for the new GCSE physics.



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More of Richard Brock's stories and anecdotes to enrich your lessons. This issue: sound.

Editorial



Welcome to the latest edition of *Classroom Physics*.

We're delighted to have secured funding for a major new project, Future Physics Leaders (see front page). FPL is part of a much bigger initiative to improve outcomes for children living in places identified as "opportunity areas" by the English government. We know that physics is one of the most enabling subjects and so providing every child with access to a high-quality physics education is an obvious route to boosting social mobility.

We will use our extensive experience of delivering CPD through the Stimulating Physics Network to form the foundations for FPL. But we are also excited to be able to trial new approaches such as sympathetic timetabling, which may improve teacher recruitment and retention in any school.

Happily, many UK schools have very healthy physics departments. Our 22nd Annual Teacher Awards (page 3) provide a welcome opportunity to showcase individual teachers – and their teams – in schools where physics teaching and learning are thriving. We applaud these wonderful teachers, whose enthusiasm and influence reach not only their own students but far beyond.

Do get in touch if you have any thoughts about what you have read in this issue or if you have any suggestions for what might be included in future issues.

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Included with this issue:

- A Pocket Physics guide – order more by emailing education@iop.org
- Marvin and Milo cards with experiments relating to sound
- Example questions for assessing ideas about energy at age 16
- A Qubit poster to promote our 16–19 e-newsletter.

International

Teaching physics and entrepreneurship in Tanzania



Students and teachers in Tanzania attempt their first Marvin and Milo experiment.

Youth unemployment in Tanzania is very high. Less than 75% of young people attend university and even those who do struggle to find employment after graduation. Coupled with this are the low numbers of university students studying physics and other STEM subjects.

What if young people in Tanzania saw the benefits of physics, or considered the important connection between science and business, or provided their own source of employment rather than seeking it from another? All three are excellent questions and difficult goals to achieve.

Working with the University of Dar es Salaam's physics department and the Optical Society of America, we are hoping to develop a sustainable, long-term programme for the future STEM business leaders of Tanzania. In August, we visited

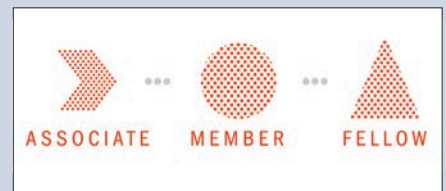
Dar es Salaam and invited sixth-form students from 13 local schools and their science teachers to try out our Ashfield and Science Ambassador workshops. We aimed to encourage teachers to include more practical activities in their lessons and to help students see the connection between science and business and entrepreneurship.

The training was a huge success. We will continue to support the students, and their schools, in their business and scientific ventures in the future.

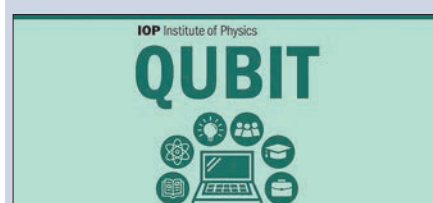
For further information: read the report of the visit by IOP international officer Linsey Clark at iopblog.org/joint-programme-helps-to-develop-tanzanias-science-business-leaders. For more about the workshops mentioned, visit stimulatingphysics.org/sas and iop.org/ashfield.

New IOP membership structure

Join a vibrant community of people who share your passion for physics. Teachers and technicians can apply for full membership or associate membership depending on their physics background. Trainee teachers are eligible for a discount rate. Full details at iop.org/membership.



16–19 e-newsletter



Our new e-newsletter for 16–19 students studying physics in the UK and Ireland offers subscribers regular updates on topics including physics news, exam and university guidance, and careers information. Encourage your students to sign up at iop.org/16-19.

Awards

Celebrating the winners of the 2017 Teachers of Physics Awards

Since 1986 we have been recognising the pivotal role that teachers play in building the physics community. The winners of this year's IOP Teacher Awards were celebrated at the IOP Awards Dinner in November, and their achievements are as exceptional as ever.

Chris Shepherd, IOP teacher support manager, said, "It is important for us to recognise the excellent work of our teachers alongside physicists from academia and industry. This year's winners have all worked

incredibly hard and have made a significant difference to the students they have taught. Their enthusiasm and professionalism are inspirational and deserve to be celebrated throughout the physics community."

The awards, to a teacher in each of Scotland, Wales and Northern Ireland, were made through peer nomination for their outstanding work as a physics teaching practitioner. The three awards presented to teachers in England were made on the basis

of their achievement in promoting the overall progression of pupils to A-level physics, the progression of girls to A-level physics or for achieving outstanding attainment of pupils in A-level physics.

Winners each receive a £300 prize, plus a crystal paperweight and a certificate, presented at the annual IOP Awards ceremony.

For more information: visit iop.org/awards.

Ireland award winner

Dr Orla Condren
*Dominican College
Sion Hill, Co Dublin*



"An excellent teacher who is continuously exploring and innovating in the classroom and is held in very high esteem throughout the school community. Orla's medical-physics background enables her to make connections between the curriculum and real-world applications, contributing to her success. Through forging strong links with the physics department at University College Dublin she has lectured student teachers, supervised them in classroom practice and developed opportunities for transition-year students to pursue research projects as work experience."

Wales award winner

Huw Smith
Ysgol Friars, Bangor



"Full of energy and enthusiasm, Huw knows his pupils well and his classroom is open every lunchtime to students who need help. He is always encouraging and reassuring, inspiring his pupils to believe that they can succeed in physics and pushing them to achieve more. As head of physics, he has grown an already-successful department, so that the uptake of AS and A-level physics has almost doubled and around a quarter of the sixth-formers now take physics, including, this year, 16 girls."

Scotland award winner

Martyn Crawshaw
*Millburn Academy,
Inverness*



"Martyn has made a very significant impact on his school's science faculty and the wider school community, and is seen as a go-to person for physics support in the north of Scotland, particularly by schools with single-teacher departments, new staff or challenging issues. His students appreciate his engaging and encouraging teaching style and his ability to relate physics to life outside the classroom, while he is a supportive and challenging mentor to new teachers."

England award winner

Paul Cooper
*Merchant Taylors'
Boys' School,
Crosby*



"Paul's inspirational leadership of a talented department has provided a rich experience for pupils both inside and outside the classroom, including lectures, university visits and regular trips to CERN. He has developed links with schools within the region, hosting physics events that have increased the numbers of students studying A-level physics. He has been instrumental in creating matched funded bursary places at the school, and in his time as head of the physics department he has helped develop the careers of many other physics teachers."

England award winner

Stephen Gascoigne
*Wickersley School
and Sports College,
Rotherham*



"An outstanding physics teacher who works tirelessly for students of all abilities. Stephen encourages students through practical activities that build both thinking and practical skills, encouraging them to deeply engage with key physics concepts. He runs drop-in sessions every week that allow students to come and ask for help or to discuss physics in general. As head of physics he has developed new strategies to improve students' enjoyment and attainment in physics, and as a result the numbers of students taking A-level physics have increased."

England award winner

Dr Zen Rogers
*Latymer
Upper School,
Hammersmith*



"Zen leads a superb team of outstandingly dedicated teachers. Between them they deliver inspirational lessons that nurture and motivate students to develop genuine intellectual curiosity and love of learning, which has made physics one of the most popular subjects at Latymer Upper. The team give generously of their time, running an Astronomy Club, Physics Forum, Aerospace Challenge and Physics Olympiad, along with trips to CERN and NASA. He is delighted to accept this award on behalf of his department."

Resources

Energy exam questions for 16 year olds

In response to teacher concerns, our education department has created example questions that students can use for practice before exams. Charles Tracy explains.

In the March *Classroom Physics*, I wrote about the revision to energy statements in the GCSE specifications for England. I said that these changes are welcome because they provide an opportunity for a rethink about energy.

Although I cannot provide any insight into what the awarding bodies will produce, I know that many teachers are concerned about what questions to expect in the new GCSE exams. Therefore, we have produced a set of questions that can be used for practice and as a basis for discussion.

The questions are structured and phrased in a way that does not rely on any particular teaching approach (either types or stores). We have tried to use language that is clear but neutral. Rather than test their proficiency in a teaching scheme, the intention is to determine whether students are able to use energy ideas in calculations and apply energy arguments in situations where they shed light on decisions or activities.

These examples should support the teaching of energy, enable students to practice without reinforcing unhelpful



Exam bodies in England are rolling out the new GCSE exams next summer.

representations of energy and illustrate what students should be able to do with energy ideas at the age of 16.

There are multiple-choice questions and structured questions (examples enclosed with this issue). As ever, we look forward to constructive conversations about the questions and how they might be used.

To download the questions: go to talkphysics.org/groups/talking-physics (no login required). Follow the changes to energy language discussion and share your thoughts by logging in at bit.ly/TPenergy.

Opinion piece

Technicians: your friends in the classroom

Paul Cook, senior lead technician at ARK Burlington Danes Academy, writes about life behind the scenes.

“Science technicians are vital members of the department. But awareness of what our role is and what we do is often lacking.

“Technicians are, by their role, problem solvers and come up with solutions often in a very short space of time. We help teachers by coaching and mentoring them in the practical activities they need to do, sharing knowledge, tips and expertise to ensure that demonstrations and experiments actually work, safely, with good practice.

“Something to remember is that technicians are outnumbered in the department and, sadly, in a growing number of schools there is only one. Anything a teacher can do to help is always appreciated. So here are some hints:

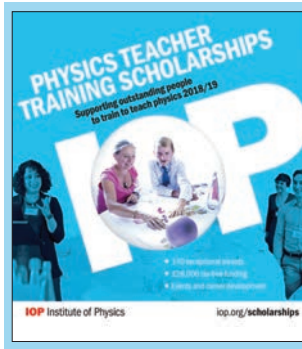
- Talk to the science technician. They know what resources are available or have ideas on alternatives. This saves time for everyone.
- I offer to go into lessons to carry out demonstrations. This is full of benefits: another body in the room, students see what a technician can do and the teacher can watch their students react.
- Get students to clear up – the room could be one of many that needs to be cleared.
- Constructive feedback is helpful, not only when things didn't go to plan – everyone likes to hear when things went well.”

Read this article in full at: iopblog.org/techniciansyour-friends-in-the-classroom.

Wales



More than 160 teachers and technicians joined the 16th Welsh Physics Teachers Conference in Christ College, Brecon, in October. As well as CPD sessions, delegates heard a talk about Einstein's obsession with the violin and how his ideas have shaped our understanding of subatomic physics.



2018 IOP scholarships: £28,000 to train to teach

We'll be offering 140 scholarships to outstanding individuals entering physics teacher training in September 2018. Successful applicants will join our IOP scholarship community with awards of £28,000 tax-free, free IOP membership, plus career-development events and networking. If you are recruiting for School Direct, make sure your applicants know about IOP scholarships. Further details at iop.org/scholarships. Sign up for our School Direct Programme at iop.org/schooldirect to receive marketing materials that you can use to promote physics teaching.

We need your help!



Can you provide classroom experience for the next generation of physics teachers? The IOP's School Experience Programme aims to match interested prospective teachers with local schools to help them gain the necessary experience to apply for teacher training. It's a great way to be in direct contact with potential trainees in your area, build community links and advertise your initial teacher education programme. We screen any participants to ensure that only suitable candidates are matched with schools. Sign up at iop.org/sepschools or email teach@iop.org.

Gender equality

Positive results from IOP school kitemark project

The Opening Doors kitemark pilot has produced impressive results after just two terms. It is based on a framework designed to reduce the negative impacts of gender stereotyping that can affect the subject and career choices, and subsequent life opportunities, of pupils. Working with King's College London and the Institute of Education, we recruited nine schools that each committed a senior lead champion and at least one other staff member.

The schools reported a step-change in awareness of gender-equality issues among staff (up more than 20% in most schools), and found colleagues willing to engage in equalities activities, despite teaching constraints (increases of 4%–20%).

By adopting a cross-departmental whole-school approach, two schools had particular success in increasing the uptake of girls in physics at A-level. Schools linked gender inequality to a wider equalities agenda, alongside issues including LGBTQ, underachievement, mental health and wellbeing, and tackling sexist behaviour, to create greater impact.

The framework concentrates on five core principles: school governance and leadership; gender discrimination and sexist behaviour; equality of opportunity and achievement, and a gender-equitable curriculum; student engagement and participation; and careers advice to students and parents to counter gender stereotypes.



Breaking down gender stereotypes across the whole school can have positive effects on everyone's subject choices.

Schools were encouraged to look closely at what is happening in their own environment and deliver targeted interventions based on their findings across the whole school.

Many of the schools plan to continue with the initiative and will share findings and strategies with other schools in their teaching network.

Read the full evaluation at: bit.ly/OpeningDoorsCharter. The kitemark project is based on recommendations from our 2015 *Opening Doors* report at bit.ly/IOPopendoors. Gender resources for teachers are at iop.org/genderbalance.

Gender champion training

We've secured funding to deliver training for whole-school gender champions in England in January/February. Schools are invited to send any staff member – teacher, librarian, counsellor, etc – who is leading the drive to counter gender stereotyping to attend these short residential courses. We'd like participants to then share what they have learnt widely, through their own school and

their networks, and will be able to apply for funding to run in-school training.

Jessica Rowson, IOP girls in physics manager, said: "Gender inequality and unconscious bias can be addressed and it's not about doing additional work: it's about looking what you could be doing differently."

To find out more, please contact sara.boiten@iop.org.

Lead school coaches to be "best qualified" leaders of physics CPD

In September we announced that the Stimulating Physics Network is inviting schools with outstanding physics departments to apply for Lead School status. Successful schools will nominate a teacher to act as a School-based Physics Coach (SPC), who will provide CPD to local school networks in return for both financial and professional reward.

SPCs will be invited to attend a three-day

residential course to prepare them to work with other teachers and lead their own CPD workshops. We will also provide SPCs with resources and guidance as they take on their new role. The event will take place in the February half-term break and both new and existing SPCs will be able to attend.

For more information or to become a Lead School, log onto stimulatingphysics.org/link-lead-schools.html.



IOP Institute of Physics Yorkshire Day

School of Physics and Astronomy,
University of Leeds

12 January 2018

All teachers of physics, technicians and trainees are welcome at this popular day for everyone teaching physics. It will be a mix of practical workshops, inspiring talks and congenial networking. Sessions concentrate on ideas to use in your labs and classrooms, including workshops on what's new about energy, make-and-take model electrical circuits, waves, unconscious bias, plus a tour of the research facilities within the university's school of physics and astronomy. Book your place at: talkphysics.org/leedsday.

SPEED2017

Netherhall School in Cambridge was the venue for the seventh annual SPEED (Stimulating Physics East of England Day) for local physics teachers and technicians. The theme was inclusive teaching strategy, and participants enjoyed workshops on electromagnetism, energy and waves follow by a carousel session with quick-fire demonstrations. Organiser Ally Davies, IOP physics network coordinator for London and the East, said: "The IOP has invested significantly in supporting schools to encourage more girls to study A-level physics. Many of our 91 delegates commented on their improved understanding of unconscious bias."

Proceedings closed with a raffle and participants took home some great physics goodies. The event was also supported by the Ogden Trust and Isaac Physics.

SPEED2017 resources are on TalkPhysics at: bit.ly/TPspeed17 or via the Twitter hashtag #SPEED2017.

Events across the regions

- 172 teachers attended our 2017 Summer Schools in Cambridge, Oxford and York. Applications for 2018 are now open to Partner Schools only, with non-Partner School applications in March 2018. Apply at stimulatingphysics.org/summer-schools.
- 70 people attended the East Midlands Network Day at Ockbrook School on 23 September.

Community



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

Drew Thomson
@mthomson

Follow

Had a great day at #IOPequality. @takeonphysics and @rowsonjessica with so many thought-provoking discussions and ideas to take away.

Student workshops

Physics on the ceiling: conservation in action

In 1707 the young, talented painter James Thornhill was given a commission beyond his wildest dreams: decorate the Painted Hall of the new Royal Naval Hospital in Greenwich.

His work earned him a fortune, a knighthood and widespread renown as the “greatest history painter this kingdom ever produced”.

Now, the ceiling is being returned to its former splendour. And, as part of Europe’s largest conservation project, schools are invited to bring their students to free workshops that explore how the physics of light is central to the restoration.

Wearing high-vis tabards and hard hats, students ascend 69 steps to the observation deck to get closer to the painting than anyone has for 300 years. They use UV and regular torches to examine the painting and reveal its damage, mirroring the expert diagnostics of conservators and

discovering repairs and additions.

Light has degraded the painting but also reveals its conservation needs. Its harmful effects are introduced by examining bleaching by UV light. This leads to discussions on refraction: varnish cracks and the consequent scattering of light make the painting appear milky.

Students test the hypothesis that blanching selectively affects darker areas. Conservators have reached different conclusions, giving the opportunity to reflect on the process of science.

The workshops are suitable for all secondary levels and combine strong curriculum links with an insight into the practical applications of science and potential careers.

For more information: visit ornc.org/workshops-for-secondary-schools.



Students investigate the role of light in the deterioration of paintings.

Old Royal Navy College

Student competition

Are your Year 12s global safe crackers?

Can your Year 12 students design a safe with locking mechanisms based on physics principles? Would they enjoy competing against other schools in a safe-cracking competition to show off their physics skills?

Each February Weizmann UK hosts a Safe Cracking Tournament at Dulwich College. Teams of five Year 12 students design and build a safe with two locking mechanisms. The safes must be able to be opened in less than five minutes by their creators but must keep their opponents stumped for at least 10 minutes. Teams swap and attempt to crack into each other’s safes by solving their opponents’ physics riddles.

The top three teams are selected to travel to the Weizmann Institute of Science in Israel for the International Safecracking

Grange Photography Ltd



A safe-cracker in action at Weizmann UK’s physics tournament.

Competition in March, with grants for flights and accommodation. The UK regularly comes in the top three places from around 30 international teams.

The tournament is CREST-accredited and students who take part can use their work to gain a Silver CREST Award. Although entry to the 2018 UK competition is now closed,

teachers who are interested in their schools competing in 2019 are invited to join the tournament for the day on Sunday 4 February.

For more information: contact Samantha Showham at Weizmann UK by email scienceeducation@weizmann.org.uk or call 020 7424 6860.

External resources

IET launches new-look Faraday websites

The Institution of Engineering and Technology (IET) has launched its new-look Faraday websites for primary and secondary schools. The aim is to make it easier for teachers, students and parents to find

information and resources linked to the IET’s education activities and STEM.

The websites offer free resources, including classroom posters, careers packs, videos, activities and lesson plans. Resources can be filtered by subject, age range, activity duration, Key Stage or by exam board.

The secondary website features a careers section with video case studies. There are

links to information on IET funding and information on the IET’s Faraday Challenge Days, which have now launched for the 2017–18 season in partnership with Thorpe Park, together with DIY Challenge Day and Faraday overseas activities.

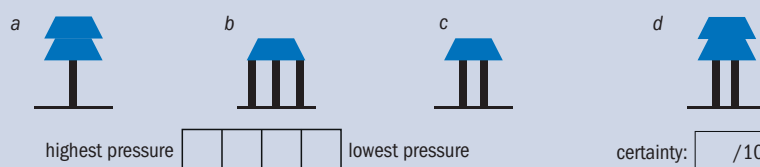
For more information: visit faraday-primary.theiet.org and ietfaraday.org.

Applying physics education research to the classroom

Ranking tasks: a tool to assess students' conceptual understanding in physics

Ranking tasks arose from the work of Robert S Seigler, who developed probes in which students made comparative judgements between variants of a context. Ranking tasks involve students sorting a number of different situations into a specified rank order. For example, in addition to setting calculation questions on pressure, a teacher might set the question as shown below:

Blue masses of equal weight are placed on black pillars of the same cross-sectional area. Rank the situations by the stress exerted on the surface on which they stand. Indicate your level of certainty (10 = completely sure/ 0 = complete guess).



It is argued that ranking tasks force students to step away from the routine use of formulae, which may become habitual, and require careful and thorough consideration of contexts before they can be successfully completed.

Credentials

A 2007 study of 250 students in the context of learning about astronomy found that using ranking tasks increased a measure of student understanding more than traditional teaching. Other recent research also suggests that ranking tasks may be effective at supporting the conceptual understanding of forces in secondary age students.

More information

A collection of ranking tasks aimed at American college students, though including many that are suitable for learners in UK secondary schools, can be found in: T L O’Kuma, D P Maloney and C J Hieggelke (eds.) *Ranking task exercises in physics*, Upper Saddle River, NJ: Prentice Hall. Full references for this article, and an example ranking task based around calculations linking force, mass and acceleration can be downloaded from the *TalkPhysics* Physics Education Research group at bit.ly/TPphyres.

This was compiled by James de Winter (Uppsala University and the University of Cambridge) and Richard Brock (King’s College London). They aim to highlight accessible and usable resources

based on research into physics education.

Join other physics teachers: for those interested in engaging with the latest research, discussing classroom

applications, attending seminars and getting involved with research, email research@teachphysics.co.uk or join the Physics Education Research (PER) group on *Talk Physics* at bit.ly/TPphyres.

Stories about physics

Sounds strange

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

Pink noise

Airbags have significantly helped to reduce injuries and fatalities in car accidents. But the sound of an airbag’s deployment can be as loud as 165 dB, leaving an estimated 17% of people with permanent hearing loss. In 2017 Mercedes Benz launched its Pre-Safe® system. This plays a burst of sound, known as pink noise, milliseconds after a collision. Pink noise has a spectral composition that has been shown to trigger a response known as the stapedius or acoustic reflex in the human ear. This contraction of the stapedius muscle results in greater acoustic impedance of the middle ear system and greater reflection of sound, protecting the inner ear. Pink noise has been described as like “diffuse traffic noise” or the “breaking of waves or a waterfall”: hear a sample at: bit.ly/MercPinkNoise.



Is this blue whale lonely – or just blue?

Wheatstone’s enchanted lyre

Charles Wheatstone is usually remembered for his eponymous bridge circuit, but he also studied sound. He found that the strings in a piano did not have to be connected directly to a resonator, and demonstrated an instrument at the Royal Institution in which the strings were joined to the sound board by 12 m deal rods. Wheatstone gave public demonstrations of an “enchanted lyre”, a small harp suspended from the ceiling by a steel cord that could produce the sounds of other instruments including a piano and a dulcimer. In fact, the steel cord ran through

the ceiling into the room above, where it was connected to the soundboards of instruments played by musicians. Despite his showmanship, Wheatstone was shy and preferred not to speak in public – Michael Faraday delivered a lecture on resonance on his behalf.

The “loneliest” whale

In 1989 researchers detected signals that sounded like the song of blue whales but were at a frequency of 52 Hz rather than the 10–40 Hz normal for this species. The media quickly described the whale as “lonely”, as it was assumed that it couldn’t communicate with other individuals of its species and a campaign raised \$300,000 to find the whale. Other researchers suggested the whale may not be “lonely” as whale songs display idiosyncratic features and group “dialects”: although the individual’s song is “odd” it is not so unusual that it can’t be heard by other whales.

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

physicsworld

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.

From hype to hyperloop

Just over 150 years since British engineer Thomas Webster Rammell built the Crystal Palace pneumatic railway in south-east London, the idea of getting from A to B inside depressurised passages is back. In 2013 Elon Musk, the multibillionaire behind Tesla electric cars and SpaceX rockets, published a white paper outlining the concept of a hyperloop: an evacuated steel tube through which passenger “pods” travel over continental distances. Thanks to the minimal air resistance, Musk claimed, the pods could be accelerated to speeds of up to 760 km/h. The hyperloop is not without its critics, branding Musk’s idea impractical, unsafe



and unrealisable. But in the four years since Musk’s paper, at least three major start-ups have been created. Author Jon Cartwright explores the history of hyperloops, the obstacles faced and the advances made.

- In the 2017 *Physics World Focus on Vacuum and Instruments*: bit.ly/PWhyperloop.

Sibling shared discovery

By the time they are 11, children who have siblings spend a third of their time – more than with their friends, parents, teachers or on their own – with their brothers or sisters. Clearly, siblings can have a big effect on each other’s life course. The bickering, fighting and arguing that is usually frowned upon or punished by parents can confer an advantage when it comes to problem-solving in adulthood – a key tool for any scientist. Benjamin Skuse discusses these ideas and looks at famous sibling physicists.

- In the August 2017 issue: bit.ly/PWsiblings.

Cassini’s grand finale

In September, the Cassini spacecraft plunged into Saturn’s atmosphere, falling silent for the first time in 13 years and ending its mission. Unlike other planetary

missions that suffered from diminishing capabilities towards the end, Cassini retained use of 11 of its 12 instruments. It flew closer to Saturn than ever before, for the first time passing in-between the rings and the planet in 22 unprecedented orbits, providing the highest ever resolution

images of the atmosphere, rings and moons. Author Joshua Colwell, one of Cassini’s co-investigators, explores how these images have enabled an entirely new investigation of the planet’s interior.

- In the September 2017 issue: bit.ly/PWcassini.

Marvin and Milo

Colour vision

Marvin and Milo are the Institute’s resident cat and dog experimenters. Every month, they come up with a new easy demo at bit.ly/IOPmandm.

DO TRY THIS AT HOME
 issue #117
 Featuring: Marvin and Milo

What you need: • Paper • Scissors • Strong glue • Coloured pens • An old CD • A marble

Make a hole at the centre of the shape, glue it to the CD and stick the marble to the CD through the hole.
 *(Get an adult to help if you use very strong glue.)

Stop the music Milo, I need to show you this experiment!

Awww

Make a circular shape from the paper using the CD to draw round. Colour it in with the rainbow colours in equal segments.

Light of certain wavelengths excites different types of cell in your eyes so you see these inputs as colours. As the CD spins, light reflected from different parts hits your eyes too fast for your brain to tell these apart so you see white light.

Spin the whole thing fast – the colours should turn to white!

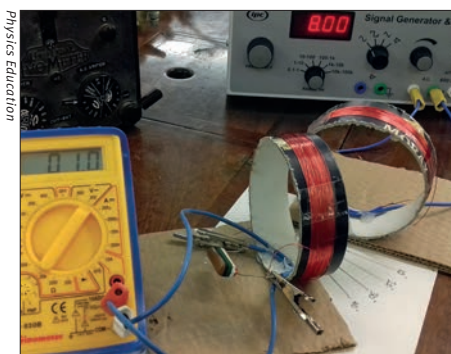
www.physics.org search term: colour vision

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.

Investigating wireless power transfer Science history lesson

I get a buzz from showing students the physics behind the latest technology. I hope it reinforces the idea that physics is an important economic driver, but even if it doesn't, it might stop students thinking that their teachers are rooted in the last century. In this paper, Stuart St John outlines how to produce and use a simple set of equipment to both demonstrate and investigate wireless power transfer. It presents some initial findings and aims to encourage physics educators and their students to conduct further research. Wireless power transfer, known to many only as a means to charge electric toothbrushes, will soon be commonplace in charging phones, electric



cars and implanted medical devices.
 ● By Stuart St John (head of physics at Queen Elizabeth Grammar School, Penrith) in the September 2017 issue: bit.ly/PEdpower.

This article is itself historic, being 50 years old. It discusses how students benefit from science history content because it's humanising and creative, and it mentions the link between physics and technology, looking backwards. What I like most are the timelines showing when scientists from different countries lived, and one showing the interconnectivity of physics and technology, although that stops prior to the transistor! Unfortunately, all those mentioned are white, male and Western. An interesting class exercise would be to update these timelines.
 ● By Professor A J Woodall (Royal Military College of Science, Shrivenham) in the November 1967 issue: bit.ly/PEdhistory.

How to balance water!

The first time I tried this I was blown away. It's the most amazing way to show how forces are distributed by a fluid. A plastic

container filled with water is balanced on a rod. What happens when a finger is placed in the water on one side of the container such that the water level rises and the consequent force downwards increases? You can feel the force on

your finger but the see-saw doesn't tip! It seemed very counter-intuitive to me. It really made me think.
 ● By David Featonby and Felix Isaac as part of the "What Happens Next" column, in the July 2017 issue: bit.ly/PEdwater.

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.

Our new graphic in the science corridor What are your favourite Lenz's law demos?

Did you know that Hollywood screen siren Hedy Lamarr patented an idea that later became the crutch of both secure military communications and mobile phone technology? That's just one thing you'd learn from the new graphic in lab technician Nick Mitchener's science corridor. "We had this done last year, designed by our then graphics tech with content supplied by the other technicians and suggestions by teachers. It forms a good counter to the more predictable pictures of the other scientists, both men and women."



● See the whole display in the *News and Comment* group at bit.ly/TPhedyL.

Lenz's law is probably the phenomenon that TalkPhysics editor Dave Cotton has the most demonstrations for. He recently found a novel application: sorting waste. Cans can be made from ferrous metals or non-ferrous metals, so they can be sorted by induced fields and Lenz's law in non-ferrous metals. Follow this discussion for more new ideas. What is your favourite Lenz's law demo?
 ● Follow the discussion in the *Talking Physics* group at bit.ly/TPLenz.

Help and advice for early-career teachers

TalkPhysics members have always been generous with their support and advice to newbie teachers, whether this is suggestions on how to teach a particular topic for the first time, advice on having their lessons observed

or what to teach in an interview lesson. Some of this year's trainees have agreed to share their experiences – the ups as well as downs – as they navigate their initial teacher education. So far, they have been excited to get started, although there are a few early worries: "I underestimated how much work needs to be done to get my biology and chemistry up to scratch!" and "Fear of the

unknown and the countless stories I am told about the huge amount of work I will have to complete in the next nine months."
 ● Follow their progress and share the wisdom of your experience in the *Talking Physics* group at bit.ly/TPiteblog. There is a TalkPhysics group specifically for early-career teachers at talkphysics.org/groups/learning-to-teach-physics.

EVENTS FOR TEACHERS

Coaching: Investigations in Newcastle-upon-Tyne

University of Northumbria

11 December 2017

This free coaching seminar is for anyone who supports teachers of physics; this may be as part of the Stimulating Physics Network, or through ITE and CPD routes. The aim is to share ideas and develop a clearer understanding of how we can best support teachers in developing investigative work.

Details and booking: bit.ly/CoachingInvestigations.

Electricity in physics

Wildern School, Southampton

12 December 2017

Boost your subject knowledge and receive practical tips to ensure fundamental ideas are understood. The session will include accurate modelling of concepts, practical troubleshooting, effective use of on-line tools and will link directly to examination-board requirements for immediate impact. Details and booking: bit.ly/ETCAlliance.

Electricity Make and Take

King Edward VI Five Ways School, Birmingham

13 December 2017

An opportunity to make a physical model of what happens in a circuit. Allow students to imagine what happens as electrons flow as a current in a circuit and how they are made to move. All parts supplied – easy assembly – a new interesting learning tool for you to take away and use right away! Details and booking: bit.ly/ElectricityMake.

Association of Science Educators Annual Conference

University of Liverpool

3–6 January 2018

With a focus on supporting practical science and an update on the International Review of Practical Science by Sir John Holman. Plus four IOP workshops. Trainee teachers can attend one day for free. Details and booking: ase.org.uk/conferences/annual-conference.

Energy in physics

Wildern School, Southampton

16 January 2018

Boost your subject knowledge and receive practical tips to ensure fundamental ideas are understood. The session will include accurate modelling of concepts, practical troubleshooting, effective use of on-line tools and will link directly to examination-board requirements for immediate impact. Details and booking: bit.ly/ETCAlliance.



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

Shocked and Stunned

Worcester University

22 January 2018

This workshop aims to improve your knowledge of how the Van de Graaff generator works and build your confidence with effective ways of using the generator in class. Details and booking: bit.ly/ShockedandStunned.

IOP North West Physics Teacher Conference

Daresbury Labs, Warrington

28 June 2018

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.

EVENTS FOR STUDENTS

Science Ambassador Training Day

Imperial College London

14 December 2017

A full day of training for groups of up to ten Year 8 and 9 students from your school run by the IOP and the Science and Technology Facilities Council, with support from mentors and STEM ambassadors. Includes team-building, presentation skills, confidence building. All-girl groups encouraged to attend. Details and booking: stimulatingphysics.org/sas.

Royal Holloway Christmas Lecture

Windsor Auditorium, Royal Holloway University

15 December 2017

This year's Physics Christmas Lecture will be delivered by Professor Glen Cowan of Royal Holloway's Centre for Particle Physics. The content will be suitable for A-level and GCSE school groups. Details and booking: bit.ly/RoyalEveningLectures.

Science Gala

University of Warwick

31 January 2018

Returning for the third year, this event provides the opportunity for students to learn more about STEM, discover career opportunities and meet inspirational scientists and learn about their research. Details and booking: bit.ly/ScienceGala18.

XMaS trip for girls

The universities of Warwick and Liverpool invite Year 12 girls to submit an essay about Rosalind Franklin to win a four-day trip to Grenoble, France. Winners will visit XMaS, the ESPRC-funded research facility at the European Synchrotron Radiation Facility and take part in the Synchrotron@schools programme. Deadline for entries is

25 February 2018. Details at bit.ly/CPxmastrip or email n.borrel@warwick.ac.uk.

Quantum engineering: leading the way to a new technological era

Boiler House Auditorium, Royal Holloway University

13 March 2018

Professor Phil Meeson will use live demonstrations of quantum physics experiments, including the famous single-photon double-slit experiment, to support a greater appreciation of the fundamental principles of quantum mechanics. Details and booking: bit.ly/RoyalEveningLectures.

The Big Bang Fair

Birmingham NEC

14–17 March 2018

Last year more than 70,000 visited this event, which aims to inspire 7–19 year olds with STEM opportunities. Registration is now open. Details and booking: thebigbangfair.co.uk.

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. Deadline for 2018: 1 February. To download an application form and for more information, visit: iop.org/schoolgrants.

Anthony Waterhouse Fellowships

Do you have an idea about physics teaching that you have always wanted to develop? These fellowships provide grants of £2000 plus support from the IOP to help you develop your idea. Applications close April 2018. More information and application forms at iop.org/waterhousefellowship.

Dots, dashes and digital circuits

In this activity, students explore how electric circuits can be used to send digital messages quickly and clearly over long distances.

Equipment required per pair of students

- Power supply, eg two D cells
- Four connecting leads
- Two long connecting leads (a series of shorter leads can be attached to make long leads)
- Two bulbs and holders
- One switch
- Two copies of the activity worksheet copied from page 12
- Writing paper

The practical activity

Students should follow the instructions on the activity worksheet to design a one-way communication link. They should work in pairs to design a circuit that contains two bulbs, one next to a switch at the “sender station” and one further away on long leads in another part of the room or behind a partition (eg a pile of books) at the “receiver station”. Once they have set up their circuits they should ensure that when they are sitting at their stations they cannot see the other station’s bulb.

Two possible designs are shown on the right. Encourage the students to sketch circuit diagrams before connecting the components. Accept any series or parallel combination that works, as long as there is a sufficient number of leads available to build it.

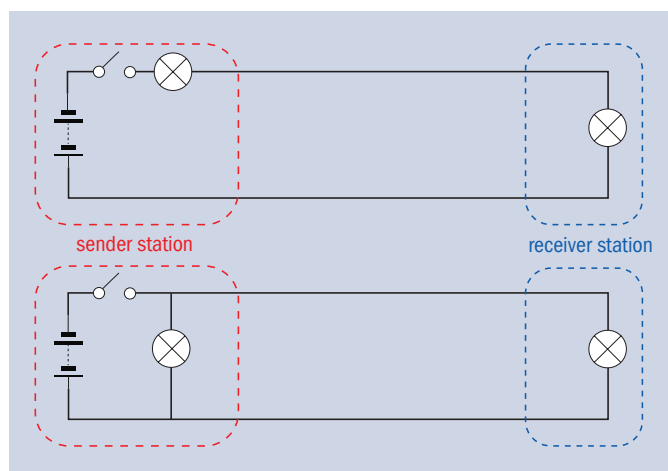
Once they have completed their one-way communication link, the students can test it by encoding letters in Morse code and sending them to their partner. Explain that they are not expected to become Morse-code experts; they are simply testing their circuit and should concentrate on sending single words or short phrases, rather than long messages (which can become very time consuming).

On their first few attempts they are likely to encode words as a continuous stream of dots and dashes with no gaps between the letters. Let them discover the pitfalls themselves and encourage them to develop their own encoding “protocols” (for example, they could simply wait for a few seconds between each letter, or transmit a very long dash to separate the letters). After sending, they should swap seats with their partner and practise receiving and decoding.

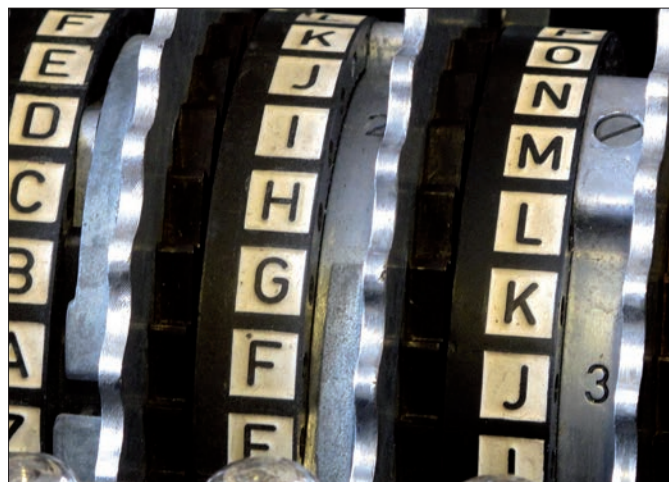
Discussion

All signals get weaker as they travel. In ground-based systems this is due to the electrical resistance of the cables; in wireless systems it’s because radio waves spread out as they travel. On the journey from sender to receiver, the message is also likely to pick up random extra signals called noise (that can be heard as crackles and hiss on analogue radio stations).

Digital encoding methods such as Morse have the advantage that the noise is usually lower in amplitude than the “on” states (the dot or dash). The signal can be more easily identified and separated from the noise than it can in an analogue voice signal. The students could investigate this for themselves by putting their hand firmly over their mouth and then, at normal volume, saying a word to their partner and then, again with their hand covering their mouth, using “bleeps” of different durations to spell out the word in Morse. They should conclude that when the signal is weak, communicating digitally allows the message to be conveyed most clearly.



Top: example of a series circuit one-way communication design.
Bottom: a parallel circuit one-way communication design.



During the Second World War, cipher machines (such as the Enigma) with multiple scramblers were used to encrypt messages. Students can build their own scrambler and investigate encryption as part of the full version of this activity at raf100schools.org.uk.

RAF100 project

This teaching tip was adapted from the RAF100 schools project.

If you want to run this activity as part of a STEM club you can extend it by asking students to investigate encryption and code-breaking during the Second World War.

The full version of this activity is available from January 2018 at:



raf100schools.org.uk

Communication circuits

In this activity you will design and build an electric circuit to send digital messages.

Encoding a message

Encoding a message means turning it into a digital signal so that it can be sent using electric circuits. One method of encoding is Morse code, in which each letter of the alphabet is represented by a series of dots and dashes.

Message	H	E	L	L	O
Encoded message-..	.-..	----

Morse code

A	.-	J	.-...-	S	...
B	----	K	---.	T	-
C	-.-.-	L	.-...	U	...-
D	---	M	--	V	...-
E	.	N	-.	W	.-..
F	..-.	O	----	X	-.--
G	---.	P	.-...-	Y	-.--
H	Q	---.-	Z	----
I	..	R	.-.-		

Instructions

- Working with your partner, design a circuit on paper so that one switch will operate two bulbs – one next to the switch, and the other on long leads to another part of the room, or behind a partition.
- Connect your circuit. Make sure that the bulbs turn on and off together when the switch is operated. Label the bulb next to the switch “sending station” and the one further away “receiver station”.
- Agree with your partner how you will signal a dot and how you will signal a dash, then one person sit at the sending station and one at the receiver station.
- Think of a word but don't tell your partner what it is.
 - Write down your word and encode it using Morse code. Send it using your circuit switching.
 - If you are at the receiver station, watch the bulb and write down the message before trying to decode it.
 - Swap seats so that both of you get a chance to send and receive messages.
- After you've both had a turn, get together with your partner and discuss:
 - Did you have any problems sending the message?
 - How did you indicate the end of a letter?
 - How could you indicate a space between words if you were to send a longer message?
- Try sending another message to see if you do better on your second attempt.



Find out more about how Morse Code was used for secret digital communications during the Second World at raf100schools.org.uk.