IOP Institute of Physics
Education Supporting Teachers

Classroomphysics
The newsletter for affiliated schools
June 2018 Issue 45

Early-career teacher retention

NQTs benefit from matched timetabling

Our newest project works with disadvantaged schools to help recruit and retain physics teachers and support them in offering matched timetabling to NQTs. Claire Aspinall, project manager of our Future Physics Leaders project, explains what this means.

There is some evidence to suggest that teachers who teach within their specialism are more likely to stay in the profession.

Workload is cited as a big factor in teacher attrition. A matched timetable maximises the number of lessons an NQT teaches within their specialism, minimising the extra preparation needed for biology and chemistry lessons. It also enables NQTs to teach repeat classes, for example, three Year 9 classes. Teaching repeat classes both reduces preparation time and empowers the new teacher to develop as a physics teacher more rapidly. It gives them the opportunity to identify common misconceptions early on in their career and develop effective pedagogical approaches to tackle them.

This isn't a reduced teaching timetable, but can considerably reduce workload in the first years of teaching. As well as making NQT positions more attractive to candidates who are physicists, it will also mean that more students have the opportunity of being taught by a subject specialist.

We are piloting this approach in our FPL Partner Schools and hope to gather more evidence of the effectiveness of this approach. Penketh High School in Warrington was one of the first schools to sign up. Their new NQT who starts in September will have a matched timetable.

Principal John Carlin said, "When you're asking people to teach outside their subject, it adds to the workload problem. Spend a year developing your craft, working on your pedagogical process so that you don't have to worry about the content and learning something new. You can just focus on being the best physics teacher you can possibly be".


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A timetable with an 80% match for physics can significantly reduce preparation time for a newly qualified physics teacher by minimising biology and chemistry teaching and by having repeat lessons.

What do you think about matched timetabling?

- Does your science department already offer NQTs a matched timetable? If so, how does your school make this possible?
- Would your school be interested in offering a matched timetable?
- Is this the best way to help NQTs develop the skills and confidence they need?

Email us **education@iop.org**

Background reading:

- The Wellcome Trust's *Improving Science Teacher Retention* report (2017) calculated that one in three science NQTs leave the state-funded sector in the first five years.
- In the DfE's *Workload Challenge* report (2015), 38% of respondents said that the amount of time spent on class preparation was unnecessarily adding to their workload.
- MetLife's 2006 *Survey of the American Teacher* found that being assigned classes they did not feel qualified to teach was the most significant factor in why teachers might leave teaching, almost doubling the likelihood.

For more information: about matched timetabling contact the Future Physics Leaders team via paul.mcdonald@iop.org.

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

In this issue

With this issue you will receive:

- an IOP energy mouse
- STFC meteorite and moon posters
- Tomorrow's Engineers careers posters
- Royal Astronomical Society careers booklet

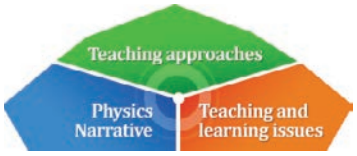
IOP RESOURCES FOR TEACHERS

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 Teacher Network

Building your own model

Gary Williams co-ordinates the IOP Teacher Network, which offers free CPD workshops, support and advice to teachers of physics across UK and Ireland. Here he describes how our Physics Network Co-ordinators (PNCs) develop ideas to share.

The model we've developed for the electric circuits day has been typical of how things happen. I had some corriflute sheets and wondered how I might use them. We'd been discussing circuit models and Drude-type physical models rolling marbles down ramps, because another PNC had written a paper on this in *Physics Education* (see p9).

I made a model and showed it off online, then another PNC made a better version and another suggested a case for the model to go in. We went out and trialled it, helping teachers to make the model in workshops.

We make the apparatus – cloud chambers, rocket launchers, water circuits, dataloggers and electromagnetic wave models – as this gives ownership of the item and develops skills. If you made it, chances are you can probably fix it, should the need arise.

Keep an eye out for the Electric Circuits day in your region!

Gary has taken up knitting

To be precise, Gary has bought a knitting machine.

A while ago, a Physics Network Co-ordinator sent Gary some knitted models of quarks in a proton and neutron. In a bid to reproduce them, he ended up making a family of quarks and an Einstein, and is now working on a Newton.

Not all the PNCs are knitters – but there might be a workshop in the pipeline near you!

Gary Williams

Woolly up, down, top, bottom, charm and strange quarks and Einstein.

For more information: find your local Physics Network Co-ordinator at iop.org/network and events near you at talkphysics.org/events.

Free resource

RAF glider kit

We are offering all readers a free 15 × glider pack (one pack per registered teacher), with everything you need for Balanced Flight activity (teacher and student notes, foam sheets and stickers). You can see the activity at bit.ly/RAF_1 – it was our Teaching Tip in the September *Classroom Physics*.

To get your kit pack:

- Register at raf100schools.org.uk
- Email RAF100@history.org.uk with the subject line "Glider Pack" and your delivery address.

Teacher support

New data protection laws and Classroom Physics

In May, new legislation about how organisations use your personal information came into force (General Data Protection Regulation). You should have received an email from us explaining how we will use your data to keep in touch with you and asking you to respond.

If you receive *Classroom Physics* as part of an agreement we have with your school, you will continue to receive paper copies and the corresponding mails. Similarly, if you have registered to receive digital copies at iop.org/classroomphysics, you will still receive our emails.

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If you didn't respond to the email, or chose not to receive updates about our work, events and opportunities, you will not receive any other communications from us.

Teaching energy

Motivating the energy mouse

We have included an energy mouse with this edition of *Classroom Physics*. These toys are captivating as they zip across the desk. And they are an excellent way of initiating and illustrating discussions about energy, how it is stored and how it is dissipated.

How to tell the energy story

A good place to start is the act of pulling back. The pulled-back mouse is storing energy. It does so by virtue of a coiled, elastic spring that has become tighter. You might say: "the mouse is storing energy elastically".

But where and how was the energy stored before? The answer is that it was stored chemically in our bodies. Put simply, our bodies allowed glucose and oxygen to react so that our muscles could do some work in pulling the mouse back. The products of the reaction (carbon dioxide and water) store less energy than the reactants.

Choosing a start point before it is pulled back and an end point afterwards, we can say that the energy stored chemically has decreased and the energy stored elastically has increased. These changes have been brought about by mechanical working (figure 1).

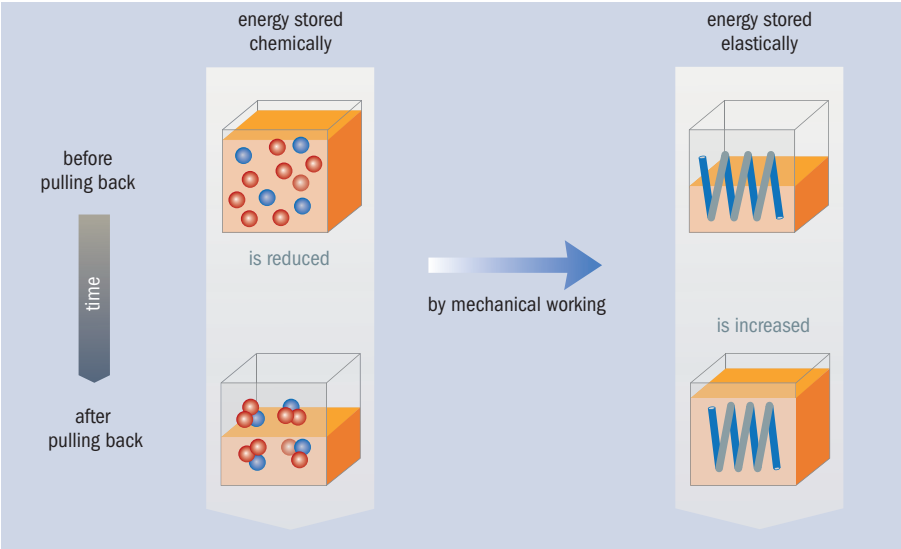

Figure 1. Illustrating the changes in the way energy is stored before and after pulling the mouse back.

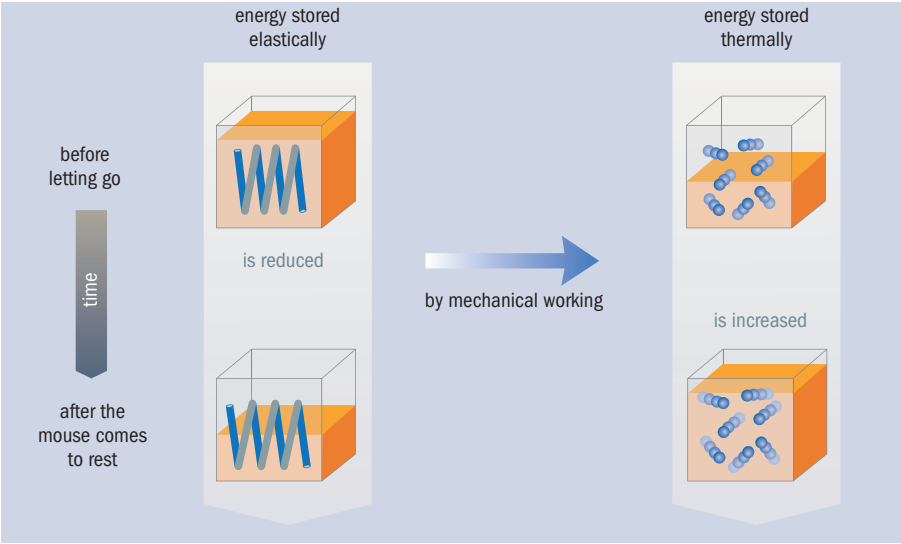

Figure 2. Illustrating how energy is dissipated in the mouse's sprint.

Choosing different start and end points

You (or your students) can choose the start and end points depending on the discussion you want to have or the analysis that you are curently doing.

For example, to start a discussion about dissipation, I suggest choosing a start point when the mouse is pulled back. The end point is when it comes to a stop having run its course. The amount of energy stored elastically has gone down (because the spring has uncoiled) and the amount of energy stored thermally (by the bearings and the surroundings) has increased. The process that led to the rise in temperature is mechanical working. This is illustrated in figure 2.

Mechanical working

It is always good to discuss the physical mechanisms by which the mouse accelerates, travels at a constant speed and slows down, all the while raising the temperature of its bearings and the surroundings. These processes are a really important part of the story, but they are separate from the energy analysis. For the whole process (pulling back, letting go and the mouse's sprint), the analysis is that the energy stored chemically is reduced and the energy stored thermally by the surroundings is increased.

Profound implications

This analysis is pleasingly simple. However, it highlights a profound and important point: the energy stored in a usable way (chemically) has decreased; it is now stored in a less usable way by a large mass whose temperature increased minutely. The total amount of energy is unchanged, but it has been dissipated. This would also be true for a bicycle ride, a car journey or an aeroplane flight.

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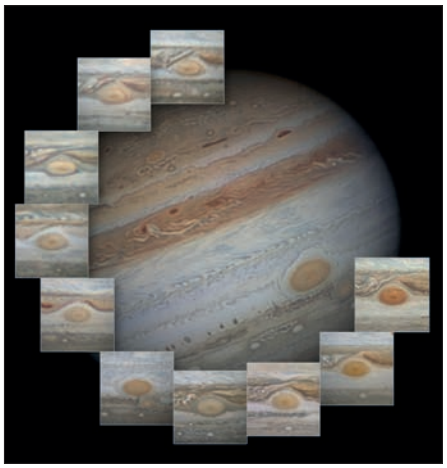
Above: An energy mouse. Left: A dissected mouse showing the coiled spring, which stores energy elastically.

The point is that journeys have a cost in terms of energy utility. To get benefit from the journey, we have reduced the usefulness of the Earth's energy stores. And we will never recover that usefulness – that is why there is currently an energy crisis.

For more information and ideas: visit www.talkphysics.org/mouse. If you post any nice ideas or pictures of uses, we will send you a dozen mice. Until they run out.

Careers



Damian Peach

Image of Jupiter showing changes in the Great Red Spot by BAA member Damian Peach.

Encouraging amateur astronomers in schools

The British Astronomical Association hopes to encourage more teachers and school students to join the great tradition of amateur astronomy by launching a digital membership package.

Jeremy Shears, BAA vice-president, explained, "Astronomy is always popular in schools and is a great way to engage in physics. We already have quite a few sixth-form students and physics teachers as members. We want to show how amateur astronomers can contribute to science through the BAA."

The BAA has been driving amateur astronomy for more than 125 years and is one of the world's leading amateur groups. It encourages amateur astronomers to make scientifically valuable observations and collaborate with professional colleagues.

Recent technological developments allow amateurs to produce better-quality images than professional telescopes captured just a few decades ago. For example, BAA member Tom Boles discovered more than 150 supernovae from his observatory in Suffolk and the planetary images of Damian Peach (see above) are among the best in the world.

At the core of the BAA's mission are observing sections, run by experts who provide guidance. The meteor section observe meteor showers equipped with just a lawn chair, a star chart and a pencil. The variable star section's observations using binoculars or small telescopes have contributed to professional research, including a *Nature* paper.

For more information: visit britastro.org. Standard digital subscriptions £29.50, senior (65+) £22.00, young person (22 or under) £12.00.

Careers

Meteorologist careers day

If you have students interested in weather and the climate, or thinking of becoming meteorologists, suggest they come along to the Royal Meteorological Society event at the IOP on Saturday 23 June. They will hear from people already working or studying in the field and will also be able to meet staff from some of the universities offering undergraduate and postgraduate courses in weather and climate. Questions can be tweeted in to the panel discussion using #RMetSCareers.

The event is free of charge but registration is required to reserve your place. Places are limited and will be allocated on a first-come, first-served basis. If your students can't make it to London, the talks will be recorded and made available online at metlink.org/careers-and-courses/career-links.

For more information: visit rmets.org/events/want-be-meteorologist-careers-information-day-young-people.

Teacher CPD and student revision

Free teacher symposium and student bootcamp

Isaac Physics is inviting teachers and their students to stay over in Cambridge for training on using their A-level and GCSE resources.

- The two-night **teacher residential symposium** (12–14 July) will be an opportunity to practise the range of questions on Isaac Physics, develop skills and discuss ideas whilst doing physics. It is available to teachers of physics (GCSE or A-level) and A-level maths (mechanics), is free to attend and supply cover costs are available to teachers in state schools with low progression to higher education. Book at bit.ly/IsaacTeacher.
- The two-night **student bootcamp** (29–31 Aug and 31 Aug – 2 Sep) is for students starting year 13 in September 2018. Students will practise the physics concepts needed to get good grades in A-level exams via mini-lectures and workshops, with experienced physics teachers and members of the Isaac Physics team on hand. Book at bit.ly/IsaacBootcamp1 or bit.ly/IsaacBootcamp2.

Isaac Physics offers a large bank of skills mastery questions for GCSE and A-level, with assignments matched to the current specifications. Students check their answers online and benefit from immediate feedback, meaning teachers do not need to check answers and can focus on giving their own expert feedback addressing student errors and misconceptions.

For more information: visit isaacphysics.org.

Term-time education visits to Jodrell Bank Discovery Centre

The Jodrell Bank Discovery Centre is a science centre in Cheshire. The term-time education programme offers unique learning experiences for learners aged 5 to 18, at a site of current and world-leading radio astronomy research. Your students can get up close to the world-famous giant Lovell telescope (the third largest fully steerable telescope in the world), as well as explore the exhibitions, and experience up to two interactive workshops. A limited number of discounted places, as well as free outreach visits, are available for qualifying secondary schools.

For more information: visit www.jodrellbank.net/learn/schools.

Improving gender balance

Mind-blowing workshops

Earlier this year, the Improving Gender Balance team ran two residential training sessions. More than 50 teachers from across the UK attended, coming from a range of backgrounds.

More than half were not science specialists and many had never been involved with IOP or gender work before – but they are all now gender champions for their schools.

They brought a variety of concerns from girls' participation in STEM to boys' behaviour and attainment across gendered subjects. This led to lively discussions, but we all came together to tackle the root causes: unconscious bias and gender stereotypes.

The training covered topics including "Unconscious Bias 101", "Building Academic Resilience" and "How to Start Conversations about Gender". We also hosted Gendered Intelligence for a special session titled "Beyond the Binary", which attendees described as "mind-blowing".

Participants also heard from existing gender champions Lynmara Hingston (Whitefield School) and Meg Greet (Eastbury Community College), who shared their experiences of setting up the programme in their schools.

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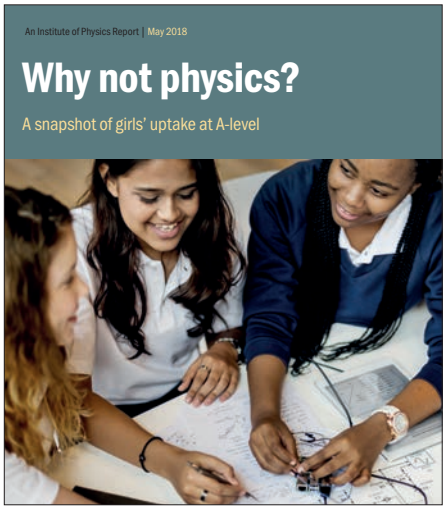
The schools involved are now setting up working groups and running their own initiatives. Several are also running outreach events with other schools, including multi-school CPD sessions, student conferences, teachmeets, primary-school workshops, student ambassador training and speaker panels.

For more information: to get involved with our gender equality work, email WholeSchoolEquality@iop.org. You can sign up for our Whole School Equality newsletter at iop.org/genderbalance or follow @IOPDiversity on Twitter.

It's slightly less different for girls now

In 2012, our publication *It's Different for Girls* revealed that almost half of maintained co-educational schools sent no girls on to A-level physics, and uptake was much higher in single-sex schools. The report recommended that schools actively challenge gender stereotyping, recognise misconceptions about girls' ability to do physics and argued that the large number of schools sending no girls to A-level was unacceptable.

In May, we launched a follow-up report, *Why not physics? A snapshot of girls' uptake at A-level*, using data from the 2016 National Pupil Database to assess what progress has been made. The situation has changed a little and there have been small improvements: a smaller proportion of schools send no girls to A-level and a larger proportion of girls progress to A-level. However, there is still a lot of important work to do to make physics openly accessible to anyone who wants to pursue it. Girls are currently less likely to progress to physics A-level than boys, even when it is one of their highest marks at GCSE.



You can read the report at bit.ly/IOPgirls2018. The core recommendations for schools include:

- routinely monitoring numbers of students progressing to A-level
- using evidence and guidance to take active measures to tackle gender inequalities and the root causes of gendered choices
- providing careers guidance that actively challenges stereotyping and allows progression to a wide number of careers.

For more information: visit iop.org/genderbalance.

STIMULATING PHYSICS NETWORK

Get your motor running – drop in electromagnetism workshop

The Rodillian Academy, WF3 3PU

5 July 2018

This workshop will help you and your students demystify electromagnetism. The session includes: hands-on practicals, revision tips for Year 11 students, when and how to include the topic in your teaching sequence, how to prevent RSI when tackling the left-hand rule, levitation...and more. Register at bit.ly/CPDElectromagnetism.

Highgate regional day

In April, teachers, trainees and technicians flocked to Highgate Senior School in north London to take part in CPD on subjects such as electrical circuits, electromagnetism and radioactivity. IOP resources manager Taj Bhutta introduced participants to the RAF100 STEM activities, which they will now take to their schools.

Participant Sandrine Bouchelkia, a senior science technician, tweeted: "Physics is definitely fun and easier than most of us think. @TakeOnPhysics organised another amazing event today at Highgate school. I have so many ideas to introduce the required practicals. Did you know you can measure the speed of light using a microwave and chocolate?"

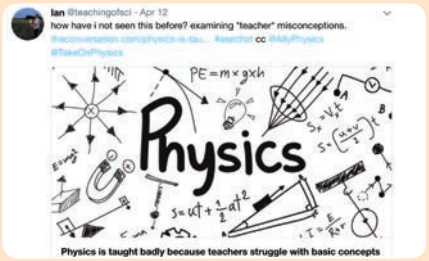
To discover and sign up for upcoming CPD days in your region, please visit stimulatingphysics.org. All RAF100 STEM activities are available for download and use at raf100schools.org.uk/activities.

Events across the regions

- The Arnewood School in New Milton joined us as a Lead School and will start in September 2018.
- 22 teachers attended a workshop on light and lenses, led by Lawrence Cattermole (south of England).
- Darren Forbes (north-west England) led a session on maths for GCSE science in March, which 16 teachers attended.

Community

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



Student research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Your students could help scientists keep track of changes in polar icebergs.

Calculate your school's carbon footprint

In November 2017, polar explorer Robert Swan and his son began an expedition to the South Pole planning to use only clean energy sources. Swan is challenging young people to remove 326 million tonnes of CO_2 from the atmosphere by 2025.

The Institute for Research in Schools (IRIS) is supporting school students in the UK to contribute to this reduction with a two-part research project called MELT.

- **Carbon footprint** – schools are being challenged to calculate their carbon footprint using a carbon calculator. Using this information it is then possible for students to develop ways to reduce the carbon output.
- **Earth observation** – students monitor the changes in the polar regions, captured by satellites. Icebergs are monitored due to the threat that they pose to ships but also because they form part of the habitat for seals, penguins and others. Icebergs are produced in a natural process known as "calving" and, in the Antarctic, some dramatic calving events have been captured. Students will share their findings with other scientists, in collaboration with Dr Anna Hogg at the Centre for Polar Observation and Modelling at the University of Leeds.

Darren Harman, STEM Learning Leader at Sir Robert Woodard Academy, commented: "MELT has presented a group of our year 9 students with an amazing opportunity to be part of novel science research, that will undoubtedly enrich their experience of learning science in a way that they wouldn't otherwise have access to until university and beyond."

For more information: visit the IRIS website and get involved with MELT at researchinschools.org/projects/melt.html.

Video resources

BoB: on demand TV and radio for schools

Have you ever seen something on broadcast TV or heard something on the radio that you'd like to be able to share with your students, but not known how to capture it to use in school? A new service allows teachers to access clips from television and radio for later use and find related video resources.

BoB is a TV and radio on-demand platform for education, created by the education charity Learning on Screen. Teachers can save, edit and stream any TV and radio programme from more than 65 national and international channels.

From *The Sky at Night* to BBC school programmes and episodes of *Horizon*, BoB contains a wealth of science – and other – programmes. There are also hundreds of films freely available.

Once a programme is saved in BoB it is available indefinitely for all account holders to use. The programmes are stored on servers managed by Learning on Screen so there is no need to worry about using drive


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space in school computers. Teachers can log in to their individual BoB accounts and request the programme.

When provided by broadcasters, transcripts can be searched for specific words. BoB will automatically find the place in the programme where the word is mentioned and this makes finding quotes and news items very easy.

For more information: visit learningonscreen.ac.uk/ondemand. UK schools with an ERA licence (era.org.uk) can have a free trial of BoB for up to one month. Email lincia@bufvc.ac.uk for further details.

Student research

Explore the depths of the Black Sea

The Black Sea Maritime Archeology Project is one of the largest and most ambitious maritime archaeology projects ever staged. It seeks to further understand the origins of the Black Sea boundaries and how sea-level change impacted early humans. It is partnering with schools across the UK to work with post-16 students who show a potential and passion for STEM subjects, but may not be aware of opportunities in STEM careers.

This summer, all secondary schools in England will receive an A1 poster highlighting careers involved in the Black Sea MAP. There will also be a supporting careers and learning resource website launching in autumn 2018.

Following residential training at the National Oceanography Centre in Southampton, selected groups of students will work alongside the team of international scientists on board the Black Sea MAP research vessel in the Black Sea discovering and learning as well as being responsible for their own projects. Other groups of students will join university researchers to analyse data and samples gathered from the field. They will be using a range of scientific techniques and technologies to uncover the mysteries of the past.

Thirty-two less-advantaged A-level students from around the UK have already taken part in the residential programme. They then either joined the research vessel during its field season in the Black Sea, or carried out projects based at the University of Southampton. Students undertook projects in geophysics, coring and science communication and entered them for CREST Awards.

For more information: visit blackseamap.com.

Students will join researchers on this vessel on the Black Sea.

Martin Hartley

Physics education

Applying research in 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.

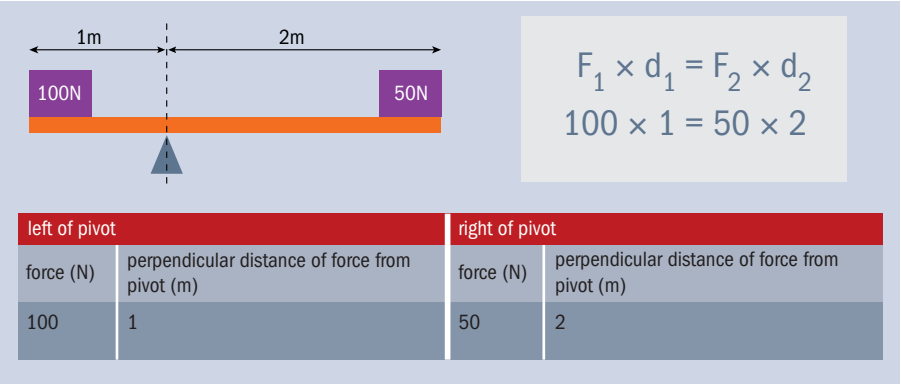
Representational fluency: becoming articulate in the language of physics

Physicists use a number of different approaches to representing information, for example, diagrams, tables and equations (see figure 1).

One of the challenges facing science learners is that the assumptions made in scientific representations (for example, the conventions used to draw force diagrams) are often not made explicit and research shows that students can struggle to understand how to transfer information between different representational formats. Teachers should therefore support their students to develop representational fluency; that is, an awareness of the conventions of different representations leading to an ability to transfer information between different presentation formats. Research also suggests that improving students' representational fluency can support their achievement in science.

A number of studies have examined the effectiveness of different approaches to supporting representational fluency in learners of different ages. The following approaches are suggested:

- explicit instruction about the assumptions of representations;
- computer simulations that encourage students to transfer information between representations;
- teacher-led dialogue about the nature of representations;
- worksheets that allow students to practise transferring information between different forms of representation.



left of pivot		right of pivot	
force (N)	perpendicular distance of force from pivot (m)	force (N)	perpendicular distance of force from pivot (m)
100	1	50	2

Figure 1. Three ways in which information about turning forces can be represented.

For more information: a sample representational fluency survey is available at bit.ly/PERfluentsurvey. A worksheet to support students' representational fluency in the contexts of free-body diagrams is available at bit.ly/PERfluentsheet. Details of research on which this column is based can be found in the TalkPhysics Physics Education Research group at bit.ly/TPphyres.

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 research@teachphysics.co.uk or join the Physics Education Research (PER) group on Talk Physics at bit.ly/TPphyres.

Richard Brock's stories about physics

Experiments to measure the light fantastic

Why 'Snell's Law' is not Snell's Law

In the first century BC, Claudius Ptolemy measured the angles of incidence and refraction for light rays passing through different materials, but did not infer a general relationship between them. The mathematical relationship referred to as Snell's Law was first described by Abu Said al-Ala Ibn Sahl around 984. It was rediscovered first by Thomas Harriot in 1602 and then Willebrord Snel van Roijen in 1621 but neither published their results. Moreover, the label "Snell's Law" is misleading because the mathematician spelled his surname with a single "l" although he used the Latin spelling, Snellius, in his correspondence. The law was independently discovered by Rene Descartes and is known as Descartes' Law in France.

Superlenses

In the 19th century, Ernst Abbe realised that lenses are limited by the effects of diffraction. Recently, however, the development of negative refractive index materials has allowed scientists to produce "superlenses", which can produce images with much greater resolutions than allowed by Abbe's limit. Superlenses are typically composed of thin sheets of metal and have a number of limitations: they absorb much radiation and must be placed very close to the object being imaged.

Help your students rediscover Snell's Law themselves at practicalphysics.org/law-refraction.

The Bucky–Einstein camera

An early patent for a "self-adjusting" camera was developed with the input of one of the 20th century's most famous physicists. Gustav Bucky, a German-American radiologist and physician, invented a system of grids that collimate X-rays and produce clearer images. While treating Einstein's wife, Elsa, the two scientists became friends and Einstein used his experience as a patent clerk to help Bucky fight infringement suits on patents he had forfeited on emigrating to the US. Bucky had developed a patent application for a camera that automatically selected an appropriate aperture setting using a photoelectric sensor. Einstein fine-tuned the plans and they were granted a joint patent. He wrote to Bucky arguing that his contributions to the camera had been minor: "I have, however, not given this thing any of my brain fat at all."

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.

Inspiring through games

Ask any scientist why they do science and they often say it's because of a deep passion to learn and understand nature. Ask a scientist why they do outreach and usually the response is to inspire more young people into science. However, there can be disadvantages to scientist-led outreach. Author Hannah Renshall explores how informal learning through avenues such as table-top games provides an effective way to engage different audiences with complex topics but also the opportunity for further discussion and debate.

- In the April 2018 issue: bit.ly/PhysicsWorldInspiring.

Sam Illingworth

The Cybathlon challenge

The 12th Winter Paralympics was held this year in South Korea; the event saw athletes with physical disabilities competing in everything from skiing to ice hockey. Rachel Brazil explores a different sporting contest, Cybathlon, held in Zurich in 2016. It showcased how science and engineering are vital for developing "assistive technology". 56 teams from 25 countries showcased their latest technologies for disabled people, with 66 drivers competing in six disciplines. These challenges centred on everyday activities that are not always easy for those with disabilities.

- In the March 2018 issue: bit.ly/PhysicsWorldCybathlon.

Rocket for rocketeers

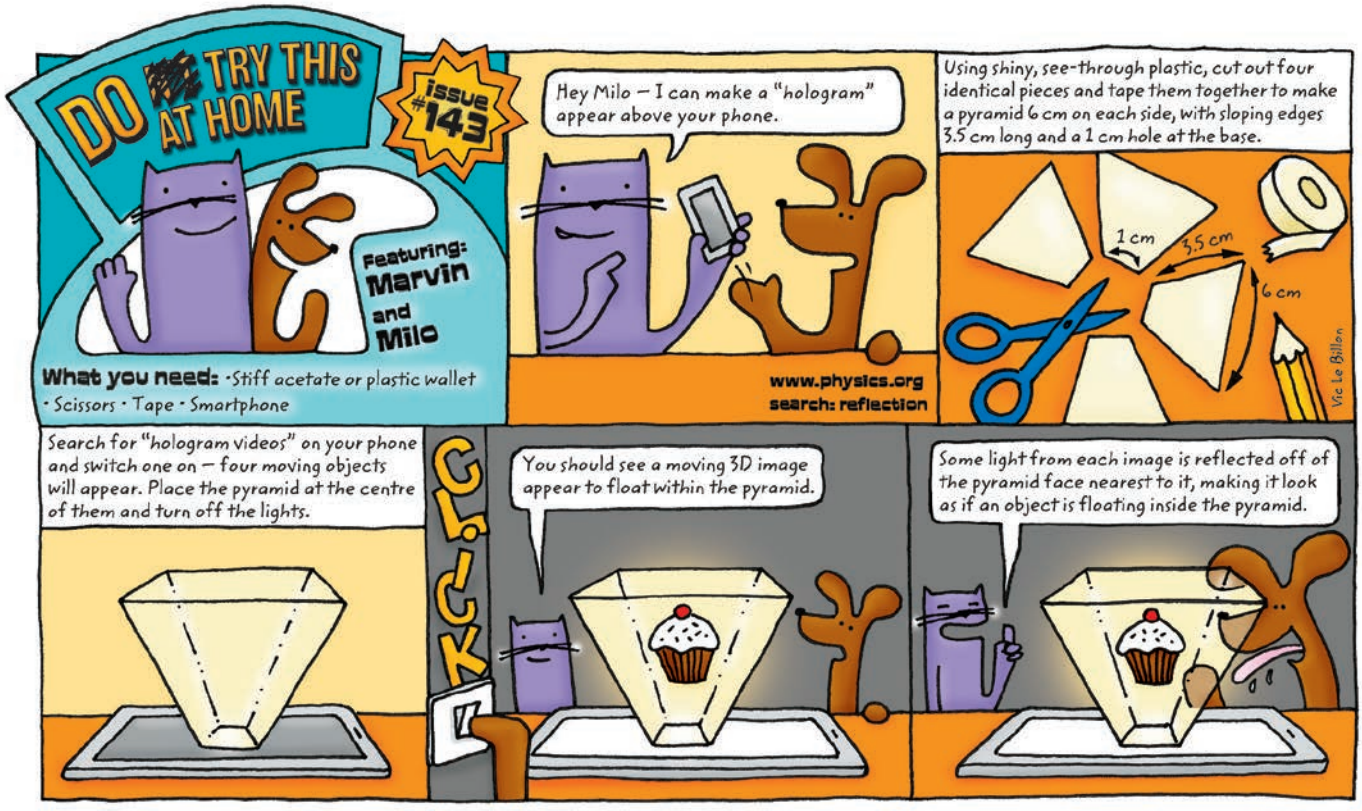
On any space mission, the amount of stored food is limited, so to survive far away from Earth astronauts need to have green fingers. In 2015 Lucie Poulet, a former crew member at the Hawaii Space Exploration Analog and Simulation (HI-SEAS) – a small research site designed to simulate life on Mars on the desolate Mauna Loa volcano on the island of Hawaii – managed to grow a crop of lettuces and radishes. Growing food on a hostile planet, or in the zero gravity of space, is no mean feat and it was far from enough to survive on. Jon Cartwright explores the challenges of growing crops in extra-terrestrial environments and the advances in plant research that may lead to us being able to provide crews on space missions with the capability to cultivate and harvest crops.

- In the April 2018 issue: bit.ly/PhysicsWorldRocket.

Marvin and Milo

Solid visions

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.



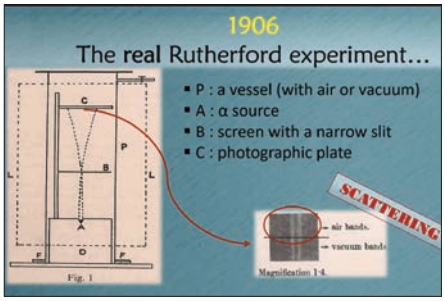
Physicseducation

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.

The experiment that never was

I felt shocked, ignorant and then satisfied when I read this paper ("Rutherford's experiment" on alpha particles scattering: the experiment that never was). As the abstract explains: "The so-called Rutherford's experiment, as it is outlined in many physics textbooks, is a case in point of the flaws around the history at the educational level of one of the decisive events of modern physics: the discovery that the atom has a nucleus..." This paper shows that this alleged experiment is a very approximate and very partial synthesis of a series of different particle-scattering

Physics Education



experiments, starting with that carried out by Rutherford in 1906 and ending with Geiger and Marsden's 1913 experiments. I for one thought it a real thing. I've even tried to make models of it. I'm now enlightened.

- By Nadia Robotti & Gaia Verna (University of Genova) and Matteo Leone (University of Turn) in the February 2018 issue: bit.ly/PEdRutherford.

Teaching electricity

As mentioned in the Teacher Network round-up, Dan Cottle and Rick Marshall have written a paper about a Drude-type model "Exploring electrical resistance: a novel kinesthetic model helps to resolve some misconceptions" (bit.ly/PEdElectric1). This has led to the development of a square circuit model, but another paper by Kevin Carlton "Teaching electric current and electrical potential" (bit.ly/PEdElectric2) contributed to the discussion. "Conceptual resources for constructing the concepts of electricity: the role of models, analogies and imagination" (bit.ly/PEdElectric3) by Taber *et al.* is connected to these ideas and is also worth reading.

John W Warren: physics rigour

"An investigation of GCE examination questions and of the numerical examples in many textbooks suggests that physics is widely regarded, not as the study of the physical world, but as a source of problems in elementary algebra." This was the opening few lines of a chapter in Warren's *The Teaching of Physics*. The book was published in 1965 but those words feel like a warning we should constantly heed. Read the *Physics Education* biography "The quest for rigour in physics – the life and legacy of John William Warren" (bit.ly/PEdWarren). Or you can read Warren's own words in "The teaching of the concept of heat" (bit.ly/PEdHeat) or "Science education and authoritarianism" (bit.ly/PEdAuth).

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.

Which teabags?

Alison posted "I would like to do the rocket/flying teabag experiment and I am struggling to find the brand of teabag that when emptied has a cylindrical shape. Please will someone advise me as to which brand to purchase." Of course, TalkPhysics users had some great suggestions. If you don't know this demonstration, it's a great way to learn about the physics of convection currents. You can find out what it is and how it works at bit.ly/IOPteabag.

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

Shutterstock

Reading club restarts with new papers

The TalkPhysics reading club is newly revived. A paper on issues in physics education will be posted with a time and date to discuss it, with a few questions to focus on. The first week looked at a York University paper entitled "Schools that make a difference to post-compulsory uptake of physical science subjects". The following week went on to IOP's 2013 report "The impact of tuition fees on prospective physics students".

- Follow the discussions in the Reading Club group at talkphysics.org/groups/book-club-ideas/.

Conservation of momentum question

Laura was wondering if anyone had a nice experimental idea to show the conservation of momentum in more than one plane. She posted, "I have finished the mechanics side of the OCR AS-level physics but my students are struggling to visualise what happens when questions ask them about a particle's motion in both *x* and *y* directions. Any ideas would be greatly appreciated." David suggested Tracker software, adding, "If you have a video (from a fixed camera) this software is great for analysis. You can play through the video with velocity and acceleration vectors shown or not. It can even show graphs of momentum and energy. These can be displayed simultaneously with the graph." This worked for Laura, but then the discussion took off when Ian suggested using an air-hockey table and users were soon off to buy desktop versions online.

- Follow the discussion in the Teaching Physics 16–19 group at bit.ly/TPmomentum.

Events

EVENTS FOR TEACHERS

How to teach radioactivity
Exeter Mathematics School, EX4 3PU
21 June
Radioactivity is often a scary topic – especially to non-specialists – but it shouldn't be! This workshop will focus on common misconceptions, the required practicals and other relevant experiments to support the safe and engaging teaching of radioactivity. All activities will be within the approved CLEAPSS guidelines as suitable for schools. Details and booking: events@exetermathematicsschool.ac.uk.

IOP South West Physics CPD Day
Ivybridge Community College, PL21 0JA
23 June
A full day of physics CPD for teachers of physics at 11–18 (all levels of experience; trainee teachers and NQTs are welcome) and technicians supporting physics teaching. The day includes a keynote presentation, networking opportunities, exhibition, workshops on the teaching and resourcing of physics topics, and a final afternoon "speed dating" session of focused teaching ideas. Lunch and refreshments provided. Details and booking: bit.ly/SWestCPD.

Royal Society Summer Science Exhibition
Carlton House Terrace, London SW1Y 5AG
2–6 July
This annual showcase of UK cutting-edge research gives students the opportunity to discuss science with the researchers making new discoveries. School groups (age 14 and above) can attend, and up to 27 students and staff are welcome. Details and booking: bit.ly/RSsummer18.

KS3/4 Electricity and GCSE Selected Required Practicals
Rugby High School, CV23 0EW
4 July
An afternoon of CPD comprising two sessions – "Introducing Electricity", which will explore innovative ways and different tricks to teach the basic concepts of potential difference (voltage), current and resistance at KS3 and how to develop them into KS4. Session two, "Required Practicals in GCSE Physics" will focus on how to deliver "F=ma" and the "Waves" required practicals. Details and booking: bit.ly/RugbyJuly.

Teach KS3/4 Physics with Confidence – Energy
Sir Christopher Hatton Academy, NN8 4RP
5 July

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

NPL Water Rocket Challenge

A free day of physics CPD for non-specialist KS3/4 physics teachers. It will include a range of practical strategies and demos, which you can immediately take back to your classroom and share with your colleagues, based on the theme of energy. In addition to the two practical sessions, the day includes a Maths for Physics session. Details and booking: teachingschool@hattonacademy.org.uk.

SPN South Regional Teacher Day
Charterhouse School, GU7 2DE
7 July
A full day of physics CPD workshops open to all teachers of physics, technicians and trainees. Including a wide range of workshops, a supplier exhibition and a chance to network with colleagues. Lunch and refreshments provided. Details and booking: bit.ly/CPDSouthRegional.

Required Practical Cheats! How to Survive with Basic Equipment
Davison CE High School for Girls, BN11 2JX
12 July
Struggling to find a class set of ripple tanks? Only have one infrared detector? Find out about our budget-friendly alternatives to help deliver the practical side of the AQA required practicals. Details and booking: bit.ly/RequiredPracticals.

EVENTS FOR STUDENTS

NPL Water Rocket Challenge
Teddington, TW11 0EB
20 June
Aim for the sky in NPL's annual Water Rocket Challenge. Schools will battle it out to become champion. The brief is to bring your own rockets and launcher to Teddington and land it exactly 70 m away. You are welcome to spectate in the evening with a view to entering in 2019. Details and registration information can be found at: npl.co.uk/wrc.

Super Physics 2018
Uppingham Community College, LE15 9TJ
6 July
An inter-school competition between teams of Year 9 students from across the East Midlands. The day features challenges, a poster competition and a lecture. Details and booking: helen.pollard@iop.org.

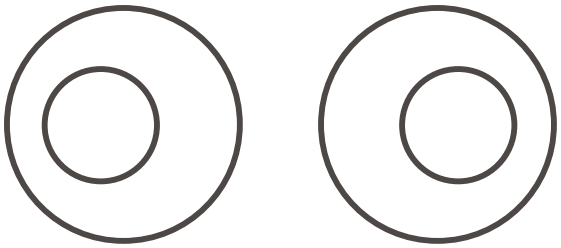
Big Bang Competition
Deadline for entries 2 November
The Big Bang Competition aims to recognise and reward young people's achievements in STEM. Students in full-time secondary education (year groups 7–13 and Scottish/NI equivalent) can enter any STEM project for a chance to win a host of amazing prizes, including the chance to be crowned UK Young Engineer of the Year or GSK UK Young Scientist of the Year. Finalists get to showcase their projects at The Big Bang Fair 2019. For more information visit: thebigbangfair.co.uk/competition.

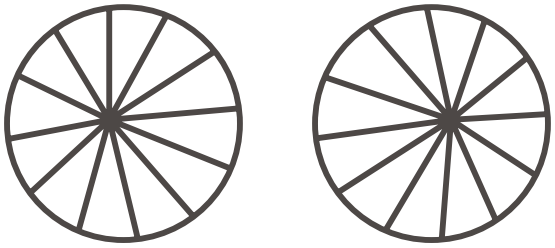
National Space Academy Year 12 Careers Conference
National Space Centre, LE4 5NS
5 and 26 November
This career conference aims to raise the profile of the space sector; allowing students to find out about the variety of careers in the UK space sector and related industries. Graduate trainees, postgraduate students and apprentices are regularly involved, giving students a chance to talk to people at an early stage in their careers about their career choices and working environments. Details and booking: bit.ly/NSACareerConf.

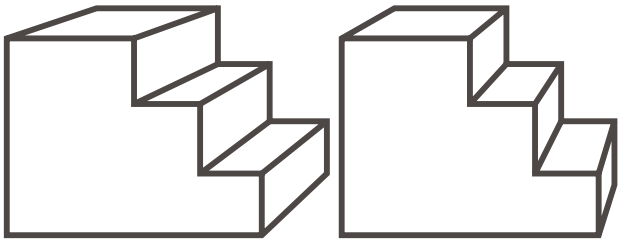
DEADLINES

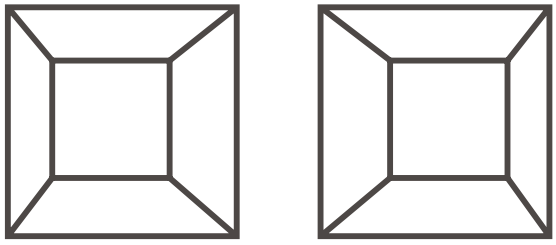
IOP School Grants
One-off grants of up to £600 for projects or events linked to teaching or promoting physics and engineering in UK schools and colleges for students aged 5–19 years. Deadlines for 2018: 1 November. To download an application form and for more information, visit: iop.org/schoolgrants.

Stereograms









Lenses and stereograms

Stereograms are a set of pictures or photographs that when viewed side by side, create a three-dimensional (3D) effect. In this activity, students explore how lenses are used for viewing stereograms.

Equipment required per pair of students

- A Google cardboard viewer (available from £2 each), with lenses removed
- The two convex/bi-convex lenses from the viewer (these have a short focal length of 4.5 cm)
- Another two identical convex/bi-convex lenses with a longer focal length and of a similar diameter to those in the viewer (eg glass lenses with a 4 cm diameter and focal length of 20 cm)
- A copy of the Stereograms sheet (p11)
- A rubber band
- A student's mobile phone

Procedure

Ask students to:

- Look at the lenses to identify which pair of lenses are fatter
- Hold one of the fat lenses in their fingers to project an image of a window onto a wall.
- Move the lens back and forth to bring the image into focus.
- Measure the distance between the image and the lens to determine the focal length.
- Repeat with the thinner lens to determine its focal length.
- To view the Stereograms sheet (page 11):
  - Mount the thin (long focal length) lenses into the viewer by sliding them between the cardboard on the eye piece
  - Fold the viewer flap out of the way and hold the viewer at a distance equal to the focal length of the lenses above the Stereograms sheet
- To view stereograms on a phone:
  - Download a pair of stereo photos (eg bit.ly/StereoPluto)
  - Display the photos full screen
  - Mount the fat (short focal length) lenses into the viewer
  - Load the mobile phone and close the viewer flap

Discussion

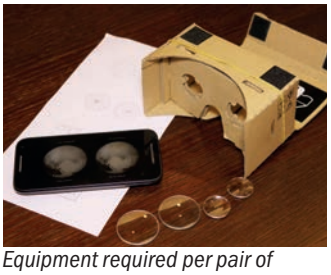
Although it is possible to view stereograms directly, without using lenses, focusing on nearby objects for a long time, can lead to eye strain. Stereoscopic viewers allow viewing with the eye muscle in the relaxed position (see diagram).

When looking at stereo pictures on a sheet of paper, viewing is by reflected light. There needs to be a large gap between the lenses and paper to allow the pictures to be illuminated. Long focal length lenses are needed. When viewing stereo photos on a mobile phone, the phone screen provides its own source of light. Short focal length lenses can be used to make a compact viewer.

Further information

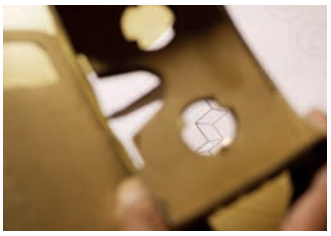
Download eight RAF themed STEM club activities at raf100schools.org.uk/activities. For alternative optics-based experiments see practicalphysics.org/optics.

Taj Bhutta is the School Support Manager at the Institute.



Equipment required per pair of students.

Image of a window focussed onto a sheet of paper using a fat lens (4.5 cm focal length).



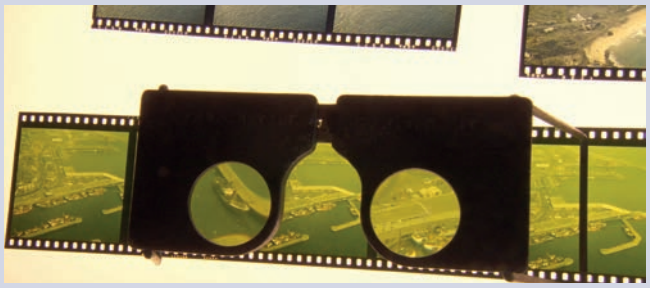
A viewer with thin (long focal length) lenses mounted for viewing the Stereograms sheet (p11).

A viewer with a mobile phone and fat (short focal length) lenses mounted.

Spying and stereoscopes

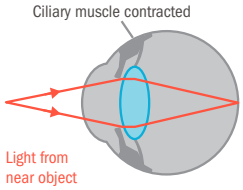
Students can explore how stereo viewers were used for aerial reconnaissance during the Cold War in activity 6 of the RAF100 STEM Club activities.

Download resources and watch our short video clip on intelligence gathering at bit.ly/RAF_6.

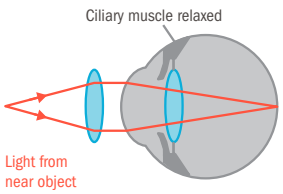


A stereoscopic viewer of the type used for aerial reconnaissance during the Cold War.

Viewing nearby objects



Focusing on nearby objects for a long time requires keeping the ciliary muscles contracted. This can lead to eye strain.



Using an additional lens in front of the eye allows images to be viewed with the muscle in the relaxed position.