IOP | Institute of Physics
Education *Supporting Teachers*

Classroomphysics

The newsletter for affiliated schools

September 2018 Issue 46

Policy

Framing future physics curricula

The IOP's Curriculum Committee has been considering how school physics curricula can give students a rewarding experience of physics. Charles Tracy, IOP head of education, describes some of the thinking so far.

Thankfully there is no appetite for major curriculum reform at the moment. Even the normal cycle of GCSE review has been suspended. However, we can think about what an education in physics to age 16 should look like and be ready for the next change.

Not only should it provide lasting and detailed skills, knowledge and understanding, but also a positive view of the discipline and its cultural contribution. We are proposing that the curriculum should be developed around big ideas and that these big ideas fall into three dimensions:

- The practices of physics
- The explanations and ideas of physics (its content)
- The applications of physics

There is only space here to begin to describe the first of these. You can read a more extensive paper online.

What are the practices of physics?

Physics is based on some important, rewarding and highly valued ways of thinking. For example, it seeks deep understanding, strives for consistency, uses reason and logic, and aims to simplify descriptions. These ways of thinking are often lost in specifications derived from detailed statements of content, making it hard to draw them out in teaching and assessment.

Furthermore, we can identify

characteristics specific to physics and its explanations: for instance, tightly defining quantities and finding numerical relationships between them.

We use the term "practices" to encompass all of these ways of thinking and characteristics. And we want them to be at the forefront of curriculum design.

Areas of practice

We found we had a list of about 30 practices. We categorised them into six areas in a way that will enable students to recognise the benefits of their experience of physics, whether or not they continue to study it.

1. **The characteristics of physics explanations:** for example, they aim to be fundamental, synthesising, unifying, consistent, simplified, economical and elegant.
2. **The development cycle of physics explanations:** the strength of the explanations comes from them becoming established through observation, reasoning, modelling, prediction and rigorous testing.
3. **Practical investigations:** setting up and performing practical activities develops both laboratory techniques and procedural knowledge.
4. **Thinking and reasoning like a physicist:** including geometric and algebraic proofs, deductive and probabilistic reasoning, and inferring the history of evolving systems.
5. **Understanding and deploying physics models:** simplifying situations and considering and using constituent parts and their properties to predict behaviour.
6. **Seeing and exploiting the power of mathematical formulations:** using numerical techniques and computational thinking to define quantities and look for relationships between them.

Our hope is that studying these practices is beneficial for all students, whether or not they continue with physics. Students will develop capability within a well-regarded set of transferrable skills whilst also gaining a lasting sense of the power and trustworthiness of physics ideas. Students should know that these concepts can be accepted with confidence because they are the result of rigorous practices of physics. In our age of relative truths and a mistrust of expertise, this seems particularly apposite.

- *This is an abridged version of a paper published in ASE journal* School Science Review.

Be part of the thinking process

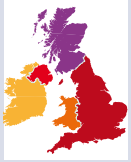
Join the discussion at talkphysics.org/groups/big-ideas.

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

In this issue

With this issue you will receive:

- Improving Gender Balance case studies
- Physics Review flyer (magazine for post-16s)
- Physics Olympiad flyer



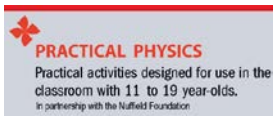
IOP RESOURCES FOR TEACHERS

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

Classroomphysics

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IOP awards

IOP honours outreach work

We are delighted that physics researcher Jess Wade (right) has been awarded the IOP's Daphne Jackson Medal and Prize for Physics Education and Public Engagement.

Jess began visiting schools as an outreach ambassador when she was studying for a PhD at Imperial College. Having come from a supportive school and a family of scientists, she was surprised to discover how different the landscape could be. "Instead of physics being the exciting, dynamic and rewarding subject I knew it was," she recalls, "it was the 'hard' subject you'd have to be a genius to take for A-level."

Now a post-doc working on chiral organic light-emitting diodes, Jess's philosophy is simple: "We need more university departments and big industry supporting school teachers and school students' parents, instead of blowing their budgets on expensive (and unnecessary) demonstrations, competitions and festivals."

Jessica Hamer, IOP project officer for improving gender balance, paid tribute:

"Jess has been an invaluable source of inspiration and assistance to the IOP's education department. She works tirelessly to improve the gender balance in physics."

For more information: full listings of the 2018 IOP award winners are at bit.ly/IOPawards18. Read our interview with Jess at iopblog.org/interview-with-dr-jess-wade and follow her blog at makingphysicsfun.com.

Teaching awards

New teachers shine

Congratulations to these two award-winning early-career physics teachers.

- **Caroline Keep** (left) of Penketh High School in Warrington won TES 2018 New Teacher of the Year. She thanked her IOP mentor, Graham Perrin, for helping her through her first years. "It was quite daunting being the only physicist in my two schools and having to develop the whole curriculum. The IOP mentoring really made a difference: just knowing someone was there to champion physics with me – the IOP and Graham were always on call." Penketh High is one of the first schools to join our Future Physics Leaders programme. It has recently begun piloting matched timetables for NQTs.

- **Charlotte Grace** (right) of Outwood Academy Shafton near Barnsley won the Silver Pearson Award for Outstanding New Teacher of the Year. Charlotte was an IOP Scholar in 2015–2016. Her citation read: "Charlotte has single-handedly transformed the chances for some of our most disadvantaged and vulnerable students through her STEM work. Each night, hundreds of students stay behind to engage with her programme."

Careers

IOP members' stories

Our members are active in education, academia, the public sector, business and industry using physics and its applications to transform our lives and society. Your students can read their stories and watch short videos about their work on our new website. Featuring a diverse selection of our members talking about their careers: achievements, educational background, career path and how they have used physics to make a difference.

David Homfray works at the UK Atomic Energy Authority: "My future goal is to do whatever I can to get electricity on the grid by fusion power."

For more information: visit beta.iop.org/member-stories.

Teacher CPD

Find your local IOP support

We have programmes of stimulating physics CPD wherever you are in the UK and Ireland, whatever your teaching specialism, however long you have been teaching, and even if you are already providing CPD for other teachers.

We've been running physics teacher CPD for almost two decades. Our teacher supporters are all very experienced teachers or former teachers. Our CPD events range from small tailored workshops for an individual school to national teacher conferences. We work with newly qualified teachers and those that support them. We support teachers who are teaching physics even though it is not their specialism, and those whose specialism is physics and who want to take their understanding and practice even further. We also work with aspiring and experienced physics coaches to enable them to support teachers in their region.

Our CPD is inclusive and non-judgemental, highly participatory, impartial, evidence-based and has been externally evaluated as impactful. And we make it free of cost to teachers.

Get in touch with your local IOP teacher supporter (choose from the mugshots below) and find out what's on offer in your region.

Scotland
Ronna Montgomery
ronnamontgomery@yahoo.co.uk

Ireland
Liz Conlon
liz.conlon@iop.org

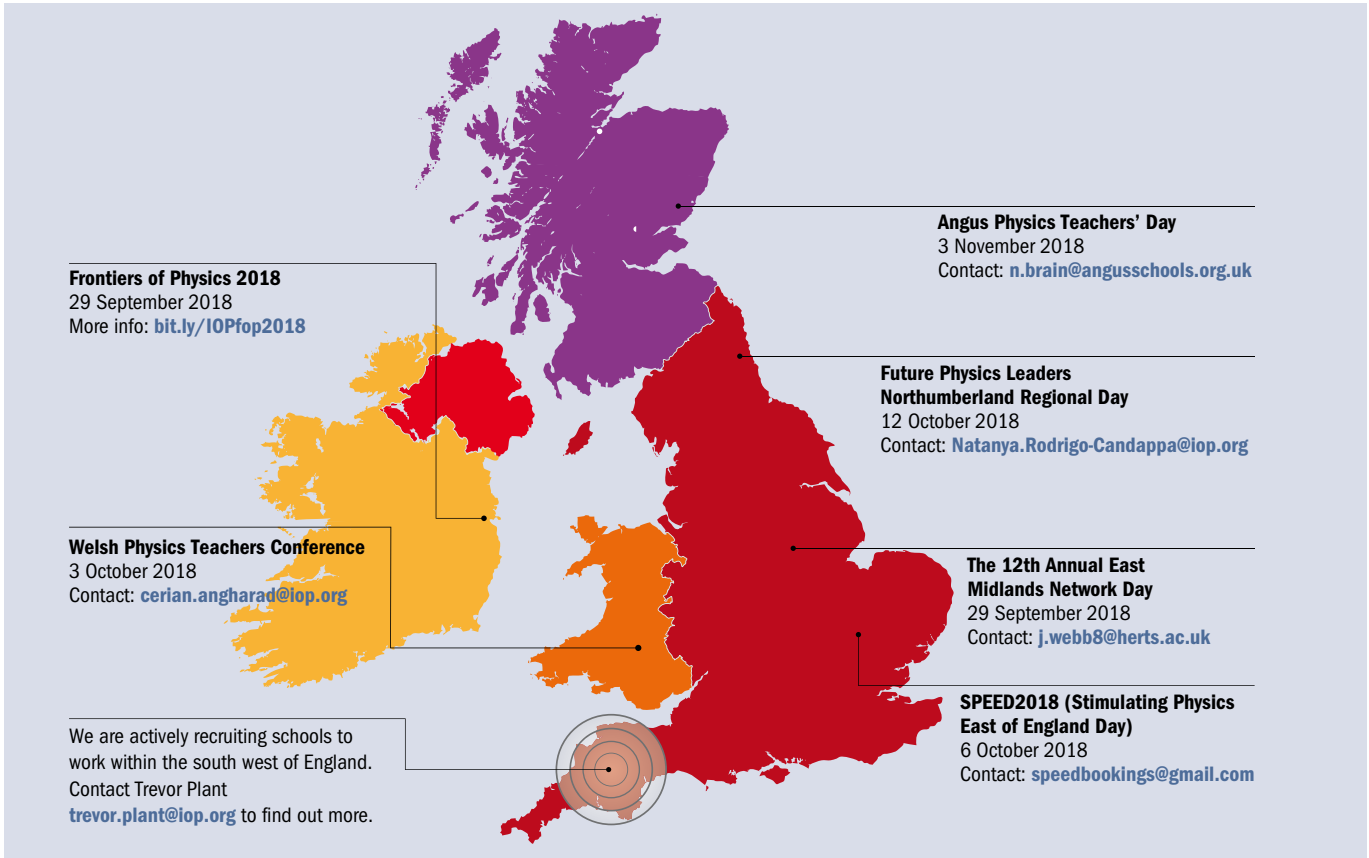
Wales
David Cunnah
david.cunnah@iop.org

Northern England
Graham Perrin
graham.perrin@iop.org

Central England
Richard Ager
richard.ager@iop.org

Southern England
Jessica Rowson
jessica.rowson@iop.org

What's on this autumn around the UK and Ireland?
Here's a selection of events – visit talkphysics.org/events to find more near you.



For more information: about the support we offer teachers, visit iop.org/education/teacher/support.

Policy

Scottish Government rolls out IOP pilot

An IOP-managed programme to improve gender balance in STEM learning is to be rolled out across Scotland. Shirley-Anne Somerville, then Scotland's Minister for Further Education, Higher Education and Science made the announcement in June.

The three-year IGB Scotland pilot ended in March and the evaluation was highly positive: 97% of respondents reported having more confidence in their ability to tackle gender-imbalance issues.

Heather Earnshaw, IGB Scotland project manager, said, "We are delighted to have the success of our approach to tackling gender imbalances in schools and early-learning centres highlighted by our government. The strength of our whole school/setting cluster approach is that it has the potential to address gender imbalances much more broadly, for example, supporting work with boys and literacy as well as girls and STEM."

She added, "Schools in Scotland – look out for the new team! Whether you are a teacher leading the way with gender balance, or someone keen to hear more – we'd love to work with you."

Somerville said that extending and embedding the IGB Scotland project was an important element in the Scottish Government's STEM Education and Training Strategy. She spoke about the need to tackle gender stereotyping, unconscious bias and gender inequity, and to do so from early-years settings upwards.

The government aims to roll out the learning from the pilot project to every school in Scotland by 2022. A team of six staff, managed by Education Scotland, will lead this next phase.

The focus of the project is helping teachers and senior managers within primary and secondary schools, and early-learning centres (ELCs), to understand gender stereotyping and develop approaches to tackle them.

Read about the innovative approaches developed by some of the schools and ELCs involved in the pilot in the enclosed IGB booklet *Case studies – Countering gender stereotypes in schools and early years education*.

Education Scotland

Kate Hutton (Skills Development Scotland), Heather Earnshaw, Ms Somerville, Charlotte Govan (IOP), Charles Tracy (IOP), Karen Murray (SDS), Ian Menzies (Education Scotland) and Beth Bramley (IOP).

For more information: to read the evaluation of IGB Scotland, visit bit.ly/IGBscotland. To download the case studies booklet, visit bit.ly/IGBcase.

Affiliated school news

Girls do physics

A school in Oxford has taken on the challenge of addressing the A-level physics gender imbalance locally by working with a neighbouring school.

Last year, the physics department at St Helen and St Katharine (SHSK), an independent girls' school that is also an IOP affiliated school, ran a "Girls do physics" programme for 30 year 9 girls from nearby mixed comprehensive Larkmead School.

Jane Edwards, SHSK head of physics explained that the girls came to SHSK for five sessions, spread throughout the year: "We aimed to develop their confidence and interest, encouraging them to continue with physics beyond GCSE. Teachers at the partner school commented that the girls exhibited greater confidence when they returned to their mixed-gender physics classes."

The inaugural session presented career opportunities available to those with a physics A-level. SHSK alumnae talked about the skills that A-level physics had provided and how it had informed their university choices and career plans. Minds were clearly opened: "I've only ever thought of being a hairdresser," said one girl at the end of the session. Other sessions included:

- A practical astrophysics workshop. The girls used Light Grapher software and analysed data from the Kepler Telescope to try to find an exoplanet.
- A biophysics session focusing on extremophile organisms: as they can live in extreme conditions on Earth, could they exist in similarly hostile environments on Mars?
- A nautical-engineering challenge investigating how the shape and size of a vessel's hull affects upthrust. Students built their own tin-foil boats, predicting the load that they could hold.
- A lab session on their current GCSE topic, energy resources and transfers, getting them to think about how to find sustainable energy for the future and the role they could play.

SHSK

Year 9 girls from Larkmead School do physics in St Helen and St Katharine's labs.

The partner school reported an 8% increase in the uptake of triple science by girls in year 9 compared to the comparable year 8 group. SHSK is planning to repeat the programme for the new year 9s and is looking forward to seeing the effect on A-level numbers in the future.

For more information: visit SHSK at bit.ly/SHSKgirls and iopblog.org/girls-do-physics.

Calling all IOP affiliated schools

We hope you enjoyed reading about SHSK. We'd like to make a regular IOP affiliated schools news feature – so if your school has been working on a project (it doesn't have to be about gender balance!) that you would like to share with other readers, please email us at **education@iop.org**.

Outreach

Physics and art make STEAM

Earlier this year, the IOP Outreach and Engagement team joined forces with the National Saturday Club network to encourage young people in Wales to use physics as inspiration for art. IOP Public Programmes Manager Toby Shannon explains.

The workshop – called the STEAM (science, technology, engineering, art and maths) Challenge – took place at Cardiff Metropolitan University. We brought together a group of young people from the art and design stream and a group from the science and engineering stream.

They looked at cosmic ray detectors, drawing on plans to install a cosmic ray detector on the roof of the new IOP building in London King's Cross. The detector will be part of the HiSPARC network, which sees secondary schools and academic institutions join forces to measure the arrival of cosmic rays.

In week one, we had a presentation and hands-on activities from the QuarkNet Cymru team, which included learning about cosmic rays, how they are detected and how our understanding of them has applications in unexpected ways, including archaeology. Artist Penelope Rose Cowley talked about how her artwork is inspired by particle physics and neuroscience.

In week two, Penelope led young people using a variety of watercolour techniques to create paintings inspired by the physics of cosmic rays. The participants produced some beautiful paintings, which formed part of the National Saturday Club exhibition held at Somerset House in London in June.

The success of the pilot means we are looking at how we can build upon it in our new building to help schools nationally and residents locally to use the arts to develop a deeper connection to physics and the IOP.

IOP

Some of the artwork produced by young people inspired by cosmic ray detectors.

For more information: about the National Saturday Clubs visit thesorrellfoundation.com. Follow progress on the new IOP building at kingscross.iop.org and find out about the HiSPARC network at hisparc.nl/en/.

School resources

Skilled speakers visit schools

Are you looking for a speaker to enthuse your budding physicists? Or can you recommend someone who has inspired your students by sharing their research interests and the opportunities that exist within physics?

Speakezee connects academic expert speakers to schools and is particularly keen to help improve gender balance at physics A-level. The service was set up by Bruce Hood, 2011's Royal Institution Christmas lecturer and professor of developmental psychology at Bristol University. He particularly wants to sign up more physicist speakers who can reach out to girls.

Professor Hood said, "We are seeking more physicists and female role models who are good communicators and enjoy outreach and public engagement. We are offering an honorarium fee as well as reasonable travel expenses for speakers who participate in this particular campaign. Sign up at Speakezee is simple and free with no obligation to accept any invitation."

Speakers are free of charge to state schools; independent schools can receive a 50% reduction in fees if they partner with a state school.

For more information: about finding a speaker, visit speakezeeschools.org. To register as a speaker, visit Speakezee.org.

CPD

Shutterstock

Joining forces gains a good reaction

An organic solution has evolved to relieve the pressure on science teachers who are hard pressed to find time for CPD in all three disciplines.

This summer saw the first joint Royal Society of Chemistry and Institute of Physics conference. The Royal Society of Biology was also a partner. It was a unique opportunity for teachers to attend a day of workshops that addressed needs across the three sciences. The day was held at the Institute of Education and was quickly fully booked, with around 80 teachers attending.

Robin Griffiths, IOP head of teacher professional support, said that this was not going to be a one-off. "The grassroots of the teaching profession love the idea of subject-specific CPD," he said. "But 'science' CPD is often less highly rated.

"This event showed that the three societies representing biology, chemistry and physics could work together to produce a CPD day with something for everyone in the science department. It was fantastic to work with the RSB and RSC to offer teachers the chance to engage with their subject and to develop skills in other specialisms. It was a phenomenal day and we're already looking forward to the next one."

The programme included a keynote address on practical science by John Holman, panel discussions on diversity in the science classroom and on careers, as well as subject specific break-out sessions and a workshop on numeracy in science.

For more information: further joint workshops will be advertised on talkphysics.org/events.

European physics

Could you put Science on Stage?

Do you have a great idea for teaching physics? The Royal Society is currently looking for applicants to present their work at the 2019 European Science on Stage (SoS) festival in Cascais, Portugal. Jennie Hargreaves teaches at Lockerbie Academy. She describes taking her project to the 2017 SoS:

Jennie Hargreaves

The Physics of Road Safety in Hungary, 2017.

After a high-profile fatal car crash in the region, my school felt more education about the dangers of driving fast was needed. We decided to adopt the methods used to calculate the speed and behaviour of vehicles in a maths and physics context. So we changed the mechanics and dynamics courses to be presented in the context of road safety.

I wanted to link this to what the police do to help students understand what goes on around them. With some funding from local industry and the Royal Society, we bought scale models of ride-on cars and 63 cm dolls. Police Scotland provided anonymised information about road incidents and we used this to create a work booklet for the students.

My project had received a European Road Safety Award, so I applied to share with others in Europe via SoS.

I was chosen as part of the UK delegation to Hungary and found myself mingling with 450 teachers from across Europe. There were talks, exhibits, displays and plenty of time to talk to other science teachers, share ideas and pick up low-cost activities that I found really helpful for my classroom.

For more information: on Jennie's project visit mrsphysics.co.uk/roadcrashsafety. To apply for SoS 2019 via the Royal Society visit bit.ly/RSsos19.

Widening participation

Jodrell Bank

Funded school visits to Jodrell Bank

This October, Jodrell Bank Discovery Centre has a special week of events. Qualifying schools can visit for free and receive a £100 bursary towards travel costs. During the visit, students will see the "The Sky's Not Your Limit" show that explores careers available in the space sector. They will have a "Meet the expert" session, where they can put questions to a researcher or engineer and then have time to explore the interactive exhibitions.

For more information: schools need to be eligible for the University of Manchester's Widening Participation Programme. Visit www.jodrellbank.net/learn/schools/WP to find out more.

Marvin and Milo

Falling through the air

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.

Applying physics education research to the classroom

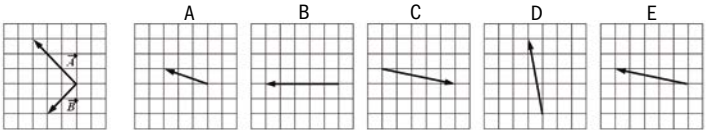
Vector concept inventories

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.

Research shows that even undergraduate students frequently make errors when working with vectors, so picking up confusion early is helpful.

In the March issue of *Classroom Physics*, we wrote about concept inventories – research-based assessments that probe students' conceptual understanding. The two vector concept inventories available on PhysPort are suitable for use with post-16 students. For school teachers, the test of understanding of vectors (TUV) assessment tool is the most relevant. Originally developed for undergraduate students, the TUV explores common errors by separating out individual components of students' understating of vectors. The TUV was developed from initial research with more than 2000 undergraduate students, and the validity of the tool was checked on a sample of more than 400 students.

We'd probably suggest that you do not use the whole assessment with your classes, but the questions and thinking behind them are useful guides. It is a good example of how researchers move from a general, nebulous problem such as "my students struggle with vectors" to a framework of what understanding vectors actually means and what the individual contributing factors are. Questions addressing each of those factors are then developed to be used for assessment and targeting student support.



Example question from a TUV (test of understanding of vectors): this figure shows vectors $\vec{A}$ and $\vec{B}$. Choose the option that shows the vector sum $\vec{A} + \vec{B}$.

Some of the most misunderstood vector concepts	
Unit vector	Graphic representation of a unit vector
Direction	Calculation of direction of vector written in unit vector notation
Subtraction	Graphical subtraction of vectors in 2D
Addition	Graphical addition of vectors in 2D

These results came from an evaluation of a TUV taken by 423 undergraduates after completing introductory physics courses.

Credentials: the TUV assessment is available from PhysPort (physport.org) in the assessments section. There is a short paper on its development (Testing Students' Understanding of Vector Concepts by Barniol and Zavala) at bit.ly/PERvectors. Additional links to research will be available on the PER Talk Physics page (bit.ly/TPperx).

For more information: 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/TPperx.

Stories about physics

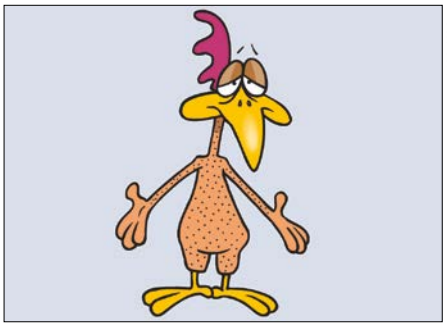
Blowing in the wind

Ways to measure wind speed

David Brewster, perhaps best known for his work on optics, idolised Newton and wrote a biography of the physicist. Brewster reports that one of Newton's earliest experiments during his teenage years was carried out in 1658 on the day of a great storm. Newton jumped first in the direction the wind was blowing and then again in the opposite direction. He measured the distance he travelled in both directions and, by comparing his measurements to the distance he could jump on a calm day, he estimated the wind speed. Enrico Fermi would follow in Newton's foot steps to determine the yield of the Trinity atomic bomb test by releasing strips of paper before, after and during the blast. He used the distance the paper travelled (roughly 2.5 m) to estimate the yield of the bomb as equivalent to 10,000 tonnes of TNT.

Counting your chickens

A curious approach to measuring wind speed was reported by the older brother of the novelist Kurt Vonnegut. In his paper, Chicken Plucking as Measure of Tornado Wind Speed, Vonnegut describes the result of an 1842 experiment in which a chicken carcass was loaded into a six-pound cannon and, it is reported, the bird's feathers rose 20–30 feet into the air, before being caught by the wind. The study's author claims a blast velocity of 341 mph was required to strip the bird of its plumage. Vonnegut reflects on the usefulness of feather removal as a measure of wind speed but notes that, in the experiment described, it is difficult to separate the effects of the explosion from the effects of the movement of the air, and suggests that wind tunnels might be used to develop a more reliable figure. The paper discusses the factors that may affect the removal of feathers from a bird and concludes that: "the plucking phenomenon is of doubtful value as an index".



Shutterstock

Can the act of plucking a chicken be used to measure tornado wind speed?

Resonance to weather the storm

Researchers seeking to understand how trees can remain standing in strong winds have discovered that all of a Douglas fir tree's larger branches have the same resonant frequency as the tree itself. This feature results in efficient energy distribution throughout the tree and effective damping of motion. The effect can be observed by watching a fir tree in high winds – whilst individual branches may display large relative displacements, the trunk moves to a much smaller degree.

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

physicsworld

Ellen Phillips, 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.

Hunting submarines from the air

To mark the centenary of the Royal Air Force, tactical co-ordinator Jason Furlong and pilot John Ryder describe how they use physics to find submarines. As with all new military technologies, the construction of submarines soon led to the development of techniques to spot enemy vessels. The authors explain how during an aerial anti-submarine warfare mission, aircraft crews use an array of hi-tech sensors to find any tell-tale trace left by a submarine as it glides under the water, and the strengths and limitations of this technology.

- In the June 2018 issue: bit.ly/PWsubmarine.


Physics World

Making health digital

With wearable tech now a staple of modern life, it's never been easier to keep track of your health. So far the functionality of commercial wearable devices has been limited: they rely on rigid electronic components mounted in plastic and few are biocompatible, washable or breathable.

What will be the next big innovation? IOP public engagement medal winner Jess Wade explores her top eight technologies-in-the-making that will lead to a new generation of health aids, from bionic eyes to artificial muscles.

- In the May 2018 issue: bit.ly/PWhealth.

Time examined and time experienced

How we perceive and experience time is fundamental to our lives but we don't fully understand what is a complex phenomenon. Philosophers and thinkers have pondered the nature of time for centuries: time both permeates all that we humans do and fascinates us when we consciously consider it. We endlessly speculate about its nature and about the possibilities of manipulating it and travelling through it. Physicists have long grappled with defining and using time as they try to explain the universe but physicists still haven't produced a full theory of time. Author Sidney Perkowitz looks at how scientists and philosophers alike are seeking to grasp this mysterious and ever-present concept. As Einstein put it, "Time and space are modes by which we think and not conditions in which we live."

- In the July 2018 issue: bit.ly/PWtime.

educationinchemistry

We've linked with the Royal Society of Chemistry to reproduce their new series of tips and classroom-ready resources for physicists and biologists teaching introductory secondary-level chemistry topics (rsc.li/EiCteach11).

How to teach hazards, safety and apparatus

Practical work brings together a range of hazards that multiply with class size. Teaching younger students about apparatus, hazards and safety is important to ensure classes run smoothly, so introduce new secondary students to good lab routines and build their confidence selecting and using appropriate apparatus as early as possible. These topics will become an important aspect of exams as they progress. Structuring learning in this area will pay dividends in the long term.

Ideas for your classroom

Consider a unit for younger students that helps them understand the special rules that apply in science labs. They are likely to have been in their normal classroom for most of their primary science. The unit might include explicit teaching and assessment of apparatus knowledge. Students' confidence will increase as they practise naming and using the tools of the lab. You could issue a safety certificate when students prove they can carry out some commonly used procedures safely.


United Nations Economic Commission for Europe

You can gamify learning about hazards and apparatus using interactive quizzes. There are three apparatus Gridlocks games: rsc.li/2ufglBA. These encourage logical thinking and familiarity with apparatus names and diagrams.

Help students select the best apparatus by getting them to think about its specific purpose. Download editable student worksheets and teacher notes for the investigation *Why are there so many pieces of equipment for measuring volume?* from the Education in Chemistry website: rsc.li/EiChazard. The activity introduces this topic using an enquiry-based approach at two different levels of difficulty.

Formative assessment

These topics are not conceptually difficult. However, regular formative assessment will help students develop the accurate vocabulary and skills they need. To check students' mastery of the topic, ask students to: sort cards to match apparatus pictures, diagrams and names (with appropriate distractors to highlight potential pitfalls); discuss their choice of apparatus for the purpose in routine practical work; collect the correct equipment from labelled drawers or trays; and design simple experiments taking into account chemical hazards.

- Kristy Turner, school teacher fellow, University of Manchester/Bolton School. Full article at rsc.li/EiChazard.

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 physics of the compact disc

I'll show my age by admitting I can remember a time before the CD. Yet I have never spent the time to find out how they really work. This paper follows the light beam through the system from the laser light source, via the disc to the photodiode detectors, explaining some of the simple ideas behind the working of the CD as well as some of the more advanced physics. Lenses, quarter-wave plates, reflection, polarisation and diffraction all get a mention: it's an excellent summary and it would be interesting to see if technology has changed much since.

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● By John A Cope in the January 1993 issue: bit.ly/PEdCD.

Tasty magic-cup illusion

This magic trick has appeared in numerous forms, including small caps to go over bottle necks, fabric-covered rings that are hard to see when wet, as well as the more usual atmospheric pressure demonstration (see Dave Featonby's paper "Magic Physics" at bit.ly/PEdmagic). This version uses fast-food cups as a way of making sure students will recall the trick every time they visit their chosen supplier of processed delicacies. Students make a small plastic disc that drops into the inverted top of an ice cream cup – linking with design and technology.

● By Nazir Amir (Academy of Singapore Teachers, Ministry of Education) in the Sept 2018 issue: bit.ly/PEdmagiccup.

Superheroes in the lab

How does Antman have the momentum needed to knock a full-sized adult over and yet ride on the back of an ant without squashing it? The increase in speed needed doesn't seem in proportion to the mass loss (if any) in the film. Similar questions can be found in this paper. The author explains that, with many students familiar with superheroes in popular films and their superpowers, superheroes offer a unique platform to motivate learning objectives in physics and promote students' critical thinking. Section titles include "Hawkeye and linear motion" and "Invisible Woman, invisibility cloaks and optics".

● By Barry W Fitzgerald (Delft University of Technology) in the April 2018 issue: bit.ly/PEdheroes.

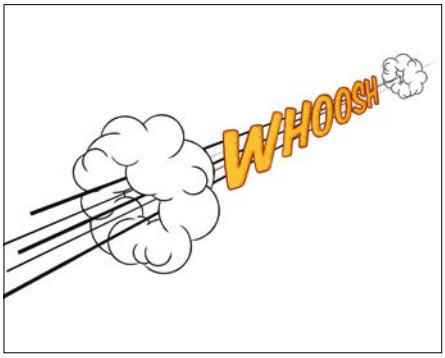
talkphysics

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.

Sound advice needed

"Determine the speed of sound in air using a 2-beam digital oscilloscope, signal generator, speaker and microphone (Edexcel Core Practical 6)." Catherine and her Lab tech could not get this practical to work. She'd tried several different microphones and bought a small amplifier but had no budget to buy more equipment unless she could be sure it would work. She is currently working through the many suggestions, tips and cheats from other TalkPhysics users. Join the discussion to find out what happened.

Shutterstock



● Follow the discussion in the *Teaching Physics 16-19* group at bit.ly/TPsound.

Engineering course preparation for university

Naomi has been asked to set up a fortnightly course to prepare students who are planning to apply for engineering this autumn at university. She asks, "Has anyone done this before? Would be happy to share ideas." Fellow TalkPhysics users came up with suggestions of websites which provide activities that Naomi could use in her sessions. In particular, there are problems to set her students that would prompt constructive discussions.

● Follow the discussions in the *News and Comment* group at bit.ly/TPengineer.

Lighting a fluorescent tube near a Van de Graaff

Tom asks: "Can anybody help explain why a fluorescent tube would light up (very briefly) when held by somebody around 1.5 m from a Van de Graaff? The person holding the tube is not touching the dome and somebody else moves the earthing dome near the Van de Graaff (these two people are not in contact). When the earthing sparks, the tube very briefly lights (faintly). It only lights on the sparking (unless moved much closer of course)." IOP teacher supporter Dave Cotton posted some great videos of how he uses his VdG and other users stepped in with their thoughts. Dan admits he makes light sabre noises when he does this demo and warned that it can affect nearby interactive whiteboards. Nick has produced a Stonehenge of upright fluorescent tubes that light up in turn as he creates an electrostatic whirl above.

● Follow the discussion in the *News and Comment* group at bit.ly/TPvdg.

Events

EVENTS FOR TEACHERS

TLIF Future Physics Leaders Stoke-on-Trent hub: Required Practicals for Non-specialist Teachers of Physics and Technicians
St Joseph's College, ST4 5NT
25 September
This workshop will look at the required practicals, examining this summer's exams and implications for classroom practice. Attendees will have the opportunity to look at some of the required practicals causing the most problems and there will also be examples of cheap and effective versions that don't need expensive equipment.
Details and booking:
bit.ly/FPLStokePraticals

The 12th Annual East Midlands Network day
Sir Jonathan North CC, LE2 6FU
29 September
The conference features a keynote lecture "Bees and Physics" by Dr Martin Bencsik of Nottingham Trent University. You also have the opportunity to choose from a busy programme of workshops, exploring ideas to use in your labs and classrooms for age 11 onwards, along with novel resources, cutting-edge applications of physics, and hands-on practicals.
Details and booking:
bit.ly/SPNEastMidlands18

Welsh Physics Teachers Conference 2018
Christ College, Brecon, LD3 8AF
3 October
This free day of workshops is open to all teachers, technicians, newly qualified and trainee teachers.
The event includes a day full of activities that can directly benefit your work as a physics teacher.
Details and registration:
bit.ly/WelshTeacherConference

SPEED (Stimulating Physics East of England Day)
Netherhall School and Sixth Form Centre, CB1 8NN
6 October
All teachers of physics, technicians and trainees are welcome. Sessions will include ideas for those new to physics teaching as well as the more experienced, with stimulating material for use in your labs and classrooms for age 11 and upwards. Refreshments and lunch provided.
Details and registration:
bit.ly/SPEED2018

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

2018 SPN Regional Day at Highgate School

TLIF Future Physics Leaders Stoke-on-Trent Hub: Electricity 1 for Non-specialists/All Teachers of Science
Excel Academy, ST1 6LG
16 October
This workshop is open to all teachers of science who teach electricity in KS3 or KS4. In this session we will look at the theory of electricity, current, voltage and resistance models, building and using circuits, and trouble shooting to help you explain electricity to students.
Details and booking: bit.ly/FPLStokeElectricity

Coaching17: Southampton
MSLC, University of Southampton
5 November
For those supporting teachers of physics: a workshop with discussions and activities. The event will have a joint focus, considering the coaching approaches needed to support misconceptions and the use of simple practicals for forces. The emphasis is on the coaching activities, rather than use directly with students.
Details and registration:
ian.horsewell@iop.org

TLIF Future Physics Leaders Stoke-on-Trent Hub: Maths for Physics – CPD for Non-specialist Teachers of Physics
Haywood Academy, ST6 7AB
6 November
This workshop is for anyone teaching physics at KS3 or KS4. In this workshop we will look at a range of maths skills that are needed for students to be successful in physics.
Details and registration:
bit.ly/FPLMathsCPD

EVENTS FOR STUDENTS

Science Ambassador Training Days – Leeds & Sunderland
Allerton High School, LS17 7AG
3 October
Sunderland College Bede Campus, SR3 4AH
10 October
A full day of training for groups of up to 10 Year 7, 8 and 9 students from your school run by the IOP, with support from local schools and universities.
Details and booking:
bit.ly/ScienceAmLeeds
or bit.ly/ScienceAmSunderland

Big Bang Competition
Deadline for entries 2 November
Students can enter any STEM project for a chance to win a host of 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.

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 November.
To download an application form and for more information visit:
iop.org/schoolgrants.

SAVE THE DATE

ASE Annual Conference 2019
University of Birmingham
9–12 January
Europe's largest science education conference with a programme of more than 350 CPD sessions, including a mini-science fair on Saturday 12 January (register for free and bring along your family who will be entertained while you pick up ideas for the classroom). New for 2019: twilight session on Thursday 10 January. For £25, teachers and technicians can attend from 3–7 pm for sessions from CLEAPSS, exam boards and ASE expert practitioners. Student teachers get a day free.
Details and registration:
ase.org.uk/annual-conference

The Association for Science Education
Promoting Excellence in Science Teaching and Learning

WORKSHEET

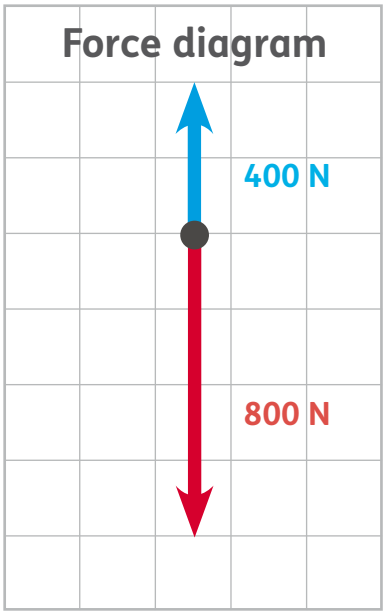
SKYDIVER CARD SORT

raf100schools.org.uk

The Royal Air Force parachute display team are called the RAF Falcons. In a practice jump an RAF Falcon jumps out of a helicopter.

1. The forces on the Falcon a few seconds into her jump are shown in the force diagram (right). What is the resultant force on her at this point in her skydive?
2. The force diagram is drawn to scale. Measure the arrows to work out what a 1 cm length represents.
3. The cards below show the Falcon at other points during the skydive and the size of the air resistance force.

   Cut out the cards, put them in the correct order and stick them in your book. Next to each card, draw labelled force diagrams using the scale you worked out in part 2.



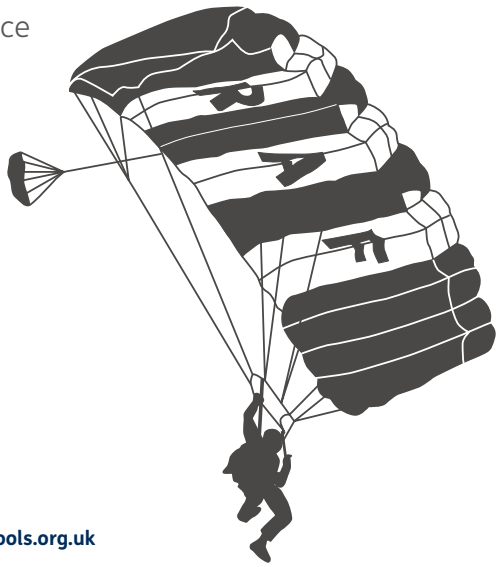
Air resistance
800 N

Air resistance
100 N

Air resistance
0 N

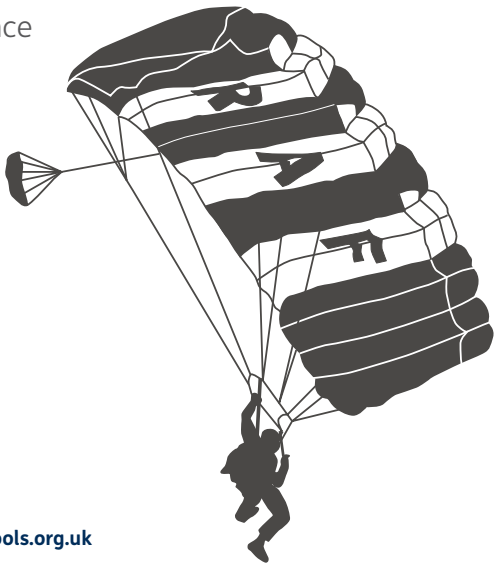
Air resistance
300 N

Air resistance
800 N



raf100schools.org.uk

Air resistance
1200 N



raf100schools.org.uk

Skydiver force diagrams

Use paper arrows to make a force diagram for a skydiver reaching terminal velocity. There is an accompanying worksheet on page 11.

Equipment required per student

- Paper of two different colours
- Coin (or counter)
- Sheet of graph paper
- Pencil
- Ruler, scissors and sticky tape

Procedure

We are using a scale of **1 cm to represent 100 N**. Ask students to:

- Cut out an 8 cm-long arrow from coloured paper
- Use sticky tape to attach the tail of the arrow to the centre of the graph paper so that it points downward. Label the arrow "gravity force"
- Cut out a 20 cm-long arrow from the other colour paper
- Wrap this arrow around a pencil and stick its tail to the centre of the graph paper so that the arrow points upwards. Label this arrow "air resistance"
- Attach a coin to the centre of the graph paper. Label it "Skydiver mass = 80 kg"

Alternatively, students could make larger force arrows and attach them to their bodies using Velcro dots. (Choose an appropriate scale to ensure that the downward gravity arrow doesn't point to an inappropriate body part).

Discussion

Ask students to unfurl the air resistance arrow to shows forces at five different stages of the skydiver's journey.

A: At the instant that the skydiver jumps out of an aircraft, the air resistance is zero and the only force acting is gravity. She accelerates downwards.
B: As speed increases so does air resistance, acting in the opposite direction to the gravity force. The skydiver's acceleration reduces.
C: When air resistance becomes large enough to balance gravity, the skydiver's speed becomes constant. She reaches terminal velocity. Its magnitude depends on how she is orientated: belly to Earth it's about 200 km/hr (120 mph). Feet/head first, it's up to 290 km/hr (180 mph).
D: When the parachute opens, air resistance becomes larger than the gravity force. The skydiver decelerates.
E: Air resistance reduces as speed reduces, so the forces become balanced again. The skydiver reaches a new lower terminal velocity of around 20 km/hr (12 mph).

For each point, they can work out:

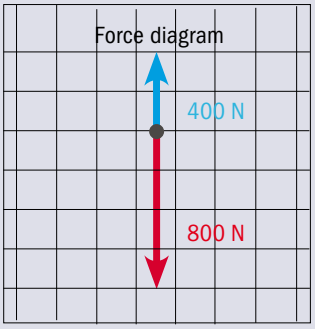
- The resultant forces using the scale of the arrows (eg if the air resistance arrow is 2 cm long, the difference in arrow length is 8 cm − 2 cm = 6 cm, and so the resultant force is 600 N)
- The acceleration by using the relationship acceleration = resultant force/mass (eg if the resultant force is 600 N, the acceleration is 600 N/80 kg = 7.5 m/s^2).

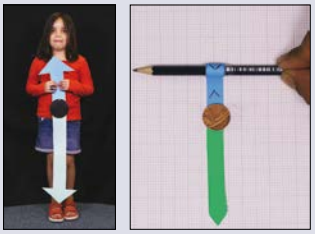
Written by **Taj Bhutta** and **Sue Woolhouse**.

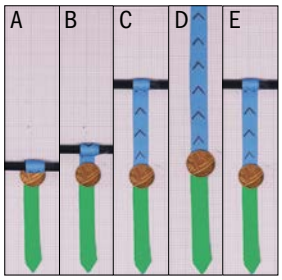
Force diagrams

- Objects are (often) represented by a small circle or dot
- Forces are represented by arrows drawn to scale
- The direction of the force is indicated by the direction of the arrow
- The size of the force is represented by the length of the arrow

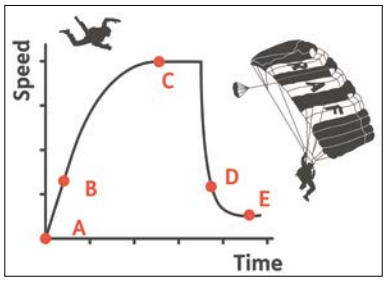
Alternatively, make force diagrams made from paper to give students a feel for them.







The paper force arrows as the skydive proceeds.



The speed/time graph of the skydive.

Skydivers on film

In videos the skydiver can seem to move upwards when he or she opens their parachute. This illusion is created by the relative motion between the camera and skydiver. The camera is held by another skydiver falling next to the first. When the first skydiver opens their parachute they slow down while the camera continues to fall past them.

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