IOP Institute of Physics
Education *Supporting Teachers*

Classroomphysics

The newsletter for affiliated schools

March 2019 Issue 48

Careers

Launch their lives with physics

From left: journalist Kelly, astrophysicist Merlin, electrical engineer Ozak, VFX artist Andy and medical engineer George feature in our poster series, Launch your life with physics.

Look out for the IOP STEM careers pack. We have sent a pack to all affiliated schools as part of our commitment to ensuring students can make well-informed choices about careers.

Taj Bhutta, IOP school support manager, said, "We hope teachers will use these posters and leaflets to encourage discussions with students about where physics can take them. Discussing careers and physics in context can be beneficial to student engagement and enable them to make more informed choices."

Included in the pack are 10 *Launch your life with physics* posters. This series features real people with physics backgrounds who work in a wide range of workplaces, both inside and outside of science. We hope that even if you don't have space for all the posters on your classroom wall, you can choose a diverse selection to show that studying physics can be for everyone.

The other resources, tailored by your location in the UK/Ireland, showcase other careers from physics and explore different routes – such as apprenticeships – available to your students after school. There are booklets and posters to help you tackle gender stereotyping in subject choice, including case studies that show how other schools have approached this.

For more information: Gatsby has developed benchmarks for good careers guidance at gatsby.org.uk/education/focus-areas/good-career-guidance. Visit our careers website at iop.org/careers, and you'll find more about physics apprenticeships at bit.ly/IOPapprenticeships. If you would like extra copies of any of the resources, email education@iop.org.

Changes to IOP Affiliation

As part of the modernisation of our publishing operation, and to ensure the Affiliation scheme remains affordable for schools, *Physics Education* will be available online-only from March.

This change will provide you with a searchable resource, including current and archived content, at iopscience.iop.org/physed. Furthermore, we will continue to feature the most classroom-ready bits of *Physics Education* in an enhanced *Classroom Physics*.

You will continue to receive print editions of *Physics World* and, of course, *Classroom Physics*, as well resources from the IOP and our partner organisations. Also, keep an eye out for our new teacher digital hub coming online later this year.

If you have any questions: about the changes to Affiliation, email affiliation@iop.org

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

Inside

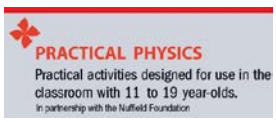
IOP RESOURCES FOR TEACHERS

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

Supporting Physics Teachers
for those teaching up to age 16
supportingphysicsteaching.net

Teaching Advanced Physics
for those teaching ages 16+
tap.iop.org

Practical Physics
for those teaching ages 11–19
practicalphysics.org



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

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IOP | Institute of Physics
Education *Supporting Teachers*

Physics in the building

IOP settles into our new home


IOP

We are now in a new home in Caledonian Road near King's Cross, in central London. Our purpose-built headquarters is designed to showcase physics in its construction, contents and the technology that staff use. Most importantly, it is also a place for the physics community, and that includes you!

Over the next few years, we will explore ways to extend the reach of our teacher CPD by running workshops in new ways: some may be physically within our building, some may be run simultaneously in several locations, and others may be broadcast online.

We look forward to welcoming you soon, either in person, or via the internet.

Physics in our building

To reduce environmental impact, our building has solar panels and plants on the roof. Inside, we have a coffee table that is a cloud chamber, motion capture technology and LiFi – the next-generation wireless network enabled by visible light. You and your students can find out about these and others features of the new IOP building at iop.org/explorephysics.

Exploring time

Our new building has a large gallery space that allows us to welcome the public – including school parties – to visit us.

The first exhibition explores the concept of time, with a video installation by Grace Weir called "Time Tries All Things".

IOP president Dame Julia Higgins said: "The concept of time spans the entire discipline of physics, from using the latest generation of space telescopes to peer back to the dawn of the universe, to ultra-fast lasers that enable us to view chemical reactions in real time. Almost everything that we do in physics is about understanding how things have changed, or will change, over time."

Future exhibitions include celebrating the 50th anniversary of the Moon landing and an interactive display exploring nuclear physics using Lego®.

Visit the exhibition: no need to book or pay, just come to 37 Caledonian Road until 29 March. School visits can be arranged by contacting toby.shannon-smith@iop.org.
Visit virtually: there are lots of online time resources at beta.iop.org/time.

Cosmic opportunities for students

In December, a group of A-level students from City and Islington College (CANDI) helped us construct a detector on the roof our new building. It is the first of its particular kind in London and will be used by the CANDI students, and other young scientists from around the world, to understand more about cosmic rays.

Our detector is part of HiSPARC, a network sited in schools and universities in the UK, Denmark, the Netherlands and Namibia. Data from the detectors can be downloaded and used for research or teaching.

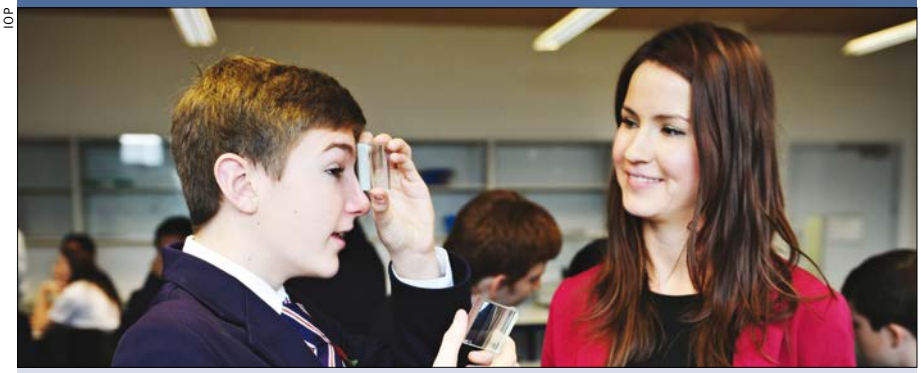

IOP

CANDI students with the IOP's Rachel Youngman (far left), Chris Shepherd (centre back) and Paul Hardaker (far right).

For more about HiSPARC and its data: visit hisparc.nl/en. For information about installing a detector at your school, contact chris.shepherd@iop.org.

Teacher retention

Join our research project to KEEP early-career physicists teaching


IOP

We're looking for schools with newly qualified physics teachers (NQTs) to help us assess the impact of a new programme of interventions. With four out of 10 NQTs leaving the profession within the first five years, and with physics NQTs more likely to leave than teachers of other subjects, we are delighted to be able to take action and develop evidence about how to ultimately improve teaching.

KEEP Teaching will assess interventions that aim to keep early-career physicists in the profession. Using a randomised controlled trial, we will test the use of some of the following:

- a subject-specific CPD programme;
- modified timetables;
- a mentoring programme;
- an initiative to support mental health and wellbeing.

"Teaching is a hugely worthwhile career," said Charles Tracy, IOP head of education. "Now there's emerging evidence on what contributes to early-career physicists leaving the profession. KEEP Teaching will test that and develop proposals that could shape the future of teacher retention and physics teaching."

Funded by the Education Endowment Foundation and the Wellcome Trust, the project will work with non-selective state secondary schools in England and will be independently evaluated by UCL Institute of Education.

There's a £250 incentive for science departments that take part.

To register your interest or find out more: visit beta.iop.org/keep-teaching. Or contact the team at KEEPTeaching@iop.org.

Government push on teacher recruitment and retention

The Institute welcomes the English government's Teacher Recruitment and Retention strategy, launched in January.

It emphasises creating a positive work environment, providing pathways for career progression and creating a climate for flexible working. It also introduces a two-year-funded early-career teacher-support framework.

As we go to press, we understand that there will be a series of workshops for heads and school leaders in March, and we would encourage colleagues to sign up. We have been in discussion with colleagues at the Department for Education (DfE) to help shape the proposals, and we are delighted to see the promise of providing subject-specific curriculum materials that will reduce the workload for early-career teachers. The IOP and other science subject associations will be working closely with the DfE to reduce the workload of teachers. Our KEEP project is one example of how we are working towards this shared goal.

To read the IOP's full response visit: bit.ly/IOPgovretention.

Teacher support

The foremost (and only?) podcast for teachers of physics

The Physics Teaching Podcast comes weekly from a garage in deepest Essex, and aims to address the fun and misconceptions of physics teaching.

Created by Robin and Thomas, both seasoned physics teachers, the podcasts are friendly romps through building contraptions, trying new things and sharing ideas. Episode titles include "Poppers", "What happens when your jelly won't hold your weight" and "Why don't more girls choose physics?".

The podcasters say: "We started this podcast to provide useful information about how some of the best physics teachers we know teach the subject. Nearly always the answer will be 'do some practical work'. We believe that physics teaching is a wonderful thing, but we are aware that not everyone agrees. The Physics Teaching Podcast is all about celebrating the professionalism of teachers of physics."

Drawing from their own experiences of teaching, Robin and Thomas saw the need for the podcast because many teachers of physics don't have the professional physics networks enjoyed by other subjects – either because they are the only physics teacher in their school or they are a teacher of another subject who is stepping up to teach physics in the absence of a specialist.

Robin and Thomas are keen to hear from you: "If you would like to be a part of physics teaching podcast history and be among our first guests, tell us about a practical you love and why, and we will be in touch."


The Physics Teaching Podcast

A motor built from bits and pieces found lying around in "Mentors, motors and merch" (podcast 9).


The Physics Teaching Podcast

Physics teaching podcasters Thomas (left) and Robin (right).

- Robin is the IOP's head of programme: teacher professional support, but podcasts in a personal capacity, and Thomas is a part-time physics teacher in Hertfordshire.

Listen or get involved by visiting: the.physicsteachingpodcast.com.

Teacher CPD

Build your own ripple tank for a fiver

The current set of GCSE required practicals expects students to understand quantitative uses of ripple tanks. This is challenging as many ripple tanks have no practical way of controlling and measuring frequency, while those with frequency and vibration generators can be expensive.

IOP physics coaches Mark Whalley and Neil Drury, have come up with a teacher workshop, which demonstrates a much cheaper version that costs somewhere between £5 and £10.

The basic ripple tank is a white lasagne dish with 1 cm of water in it. A ruler runs along the edge of the dish and a simple wooden beam is suspended on lengths of sewing elastic from another clamped beam. This is lowered into the dish and the beam is then tapped to create wavefronts.

Mark Whalley

This cheap and controllable ripple tank is made from a lasagne dish.

To get a 4 Hz source, tap the beam in time while saying "Mississippi", which has four syllables and so takes about one second to say – similarly, saying "elephant" gives you a 3 Hz source. Video the waves with a mobile phone so that you can replay and pause to read off the wavelength from the ruler. A touch of food colouring improves the contrast of the waves, especially when videoed.

It isn't fancy and there are shortcomings, but it is very cheap and it means that students can actually do the experiment rather than just watching a demo, which is priceless.

For more information: visit the Waves thread in the Required GCSE Practicals group on TalkPhysics at talkphysics.org/groups/required-gcse-practicals-from-2016.

Black holes in the classroom

Teachers from North West England recently got an insight into some of the latest physics research from the University of Lancaster, and thought about how it might be used in the classroom.

The CPD day was organised by IOP physics coach for Cumbria Phil Furneaux, partnering with the Ogden Trust. Delegates explored the latest thinking on galaxy formation, black holes and supernovae. They then discussed how this might be brought into lessons on the electromagnetic spectrum and more widely about linking current university research with curriculum topics.

Hands-on activities included working with astrophysics researchers to measure red shift from real data, and discovering how this technique is used to create a 3D map of the universe. They also measured galactic rotation using computer simulation and found out how this shows evidence of dark matter.

NASA

An image of the supernova remnant HBH 3 taken by NASA's Spitzer Space Telescope.

To find events organised by your local physics coach: visit talkphysics.org/event. Phil's next workshop, entitled Using Space to Teach Magnetic Fields, takes place on 31 May. Details at bit.ly/CPusingspace.

Teacher CPD at science museums

Look out for free courses at the Science and Industry Museum in Manchester and the Science Museum in London.

There are three courses for teachers: science engagement, science beyond the classroom and science discussion for the classroom. These hands-on sessions allow teachers to try a range of techniques and resources designed to help engage students. They also demonstrate the relevance of STEM by linking classroom learning to students' everyday lives.

Attendees will come away with a range of new ideas, including how to build enquiry and thinking skills.

The fully-funded courses are run during the day in term time, but there are twilight sessions for schools in the Greater London area.

For more information: visit bit.ly/CPscimus, or email smgacademy@sciencemuseum.ac.uk.

Student CPD

Jobs for girls and boys

Redmoor Academy in the East Midlands held an Equality Day last term. IOP physics coaches Sarah Cosgriff and Nicky Thomas ran sessions for years 7–9.

"Our aim was to show students that stereotypes about their gender should not limit what they want to do.

"We discussed jobs and associations of gender using the examples of a nurse (female dominated) and a firefighter (male dominated). We argued that they required the same characteristics, such as being strong, caring and sympathetic. The students engaged enthusiastically. At the end, they reflected on what they had heard and thought about how they break stereotypes themselves.

"The take-home message is that following stereotypes is not necessarily a bad thing, but it should not define who you are or what you are expected to do."

Pupils discussed words often attributed to girls (pink) and boys (blue).

For more information: about our gender balance work, visit iop.org/genderresources. Look for workshops near you at talkphysics.org/events.

Student science

Getting involved in an international research journal

Mhairi McCann finished school last year and is currently the chief editor of the *Young Scientists Journal* (YSJ), an international peer-reviewed scientific journal written, edited and published by 12- to 20-year-olds.

It's a great pleasure to work alongside a varied and awesome team of more than 80 young people. I first got involved with the journal in 2016 through a poster presentation at the YSJ Annual Conference. I was sharing the work that I'd done during my Nuffield Research Placement, and from there, I became the journal's ambassador to Scotland.

The roles in our team of volunteers are varied: editing articles, producing original artwork, building the website, managing our social-media feeds and more! There's a role for everyone, and we're always on the lookout for enthusiastic people to join our team. Groups of students can also get involved by setting up a hub at their school, where – supported by a teacher – they become a localised hotspot of YSJ activity.

I'm not sure what I want to do next in terms of education or career. But being part of YSJ is a hugely enjoyable experience and I'm learning a lot.

For more information: visit ysjournal.com/join-the-team. The 2019 YSL conference takes place on 2 October 2019 at Queen's College Cambridge.

Applied research

Ilya Carey published a paper in October 2018's YSJ, based on findings from his year 12 extended project qualification: "Effects of heat on colour and iridescence of Chrysochroa wallacei beetle". Using physics knowledge gained in the classroom, Ilya undertook original and scientifically important research that could have applications for thermosensitive surfaces.

- Read Ilya's article in full at bit.ly/YSJbeetle.

YOUNG SCIENTISTS journal

Shutterstock

Grants

Up to £15,000 for your STEM project

The IET and IMechE's Engineering Education Grant Scheme is for UK-based projects teaching primary or secondary students about engineering, or improving their knowledge of engineering more widely. The scheme also supports projects that develop the skills of those promoting STEM learning and careers awareness. Most awards will be up to £5,000, but a small number will be up to £15,000 for big-impact projects. Applications from partnerships are particularly welcomed. All projects must involve IET or IMechE members.

IET The Institution of Engineering and Technology — Institution of Mechanical Engineers

For more information: visit theiet.org/fund. The next application deadline is 29 March for projects starting from 1 June.

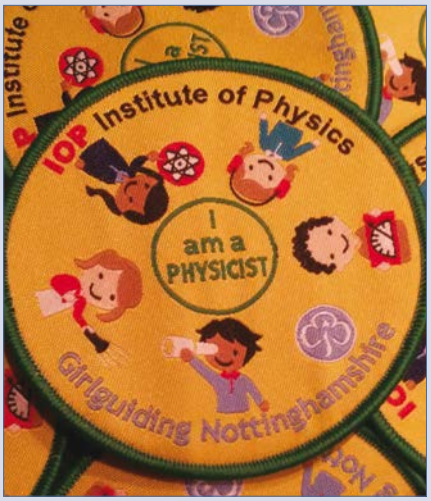
Awards

Get your technician recognised

Nominate your science technician for a Salters' National award. The aim of the award is to highlight the importance of technicians in enabling high-quality practical work in science, in schools and colleges, with the emphasis on promoting and supporting the professional learning and upskilling of technician teams (sole technicians are still eligible). The winners will receive £1,000 each.

For more information: and to apply online, please visit saltersinstitute.co.uk. The closing date for applications is 3 May.

Brownie points for doing physics

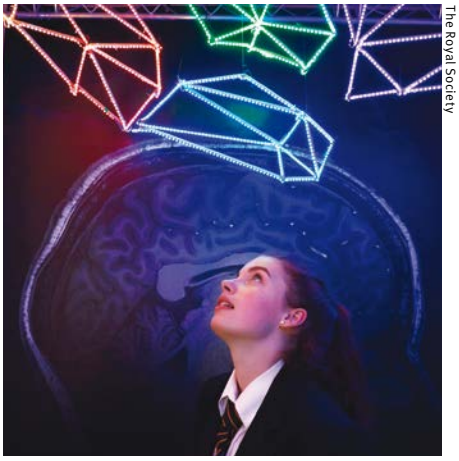


Deborah Phelps

Brownies and Guides in the East Midlands are piloting a new badge, "I am a physicist". It is the brainchild of Deborah Phelps, a member of the IOP's Council and an engineer at Rolls-Royce. To take part in the challenge, you don't need to be a Girlguiding member. Visit beta.iop.org/introducing-i-am-physicist-challenge and download resources suitable for 5- to 18-year-olds.

Student science

The Royal Society's special days for sixth formers



The Royal Society

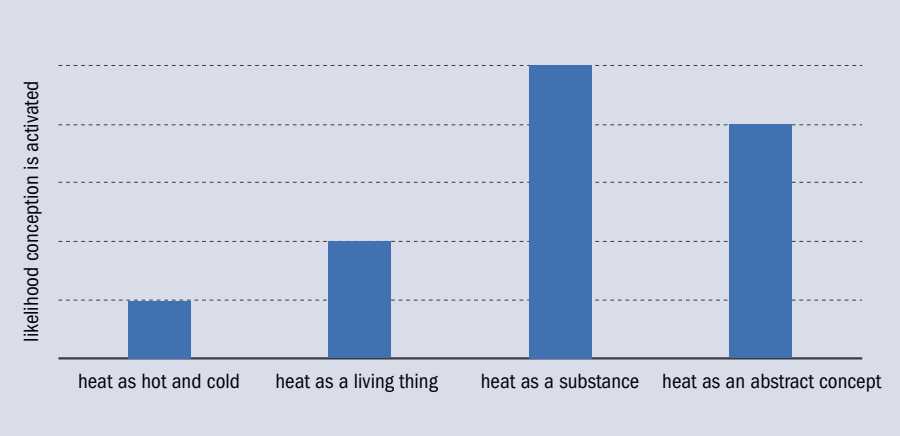
The Royal Society's Summer Science Exhibition will take place from 1–7 July. This year, the Wednesday and Thursday will target students studying STEM A-levels, or equivalent, and their teachers. Those booked on these days will get a full day to explore the exhibition and speak in-depth to researchers, finding out more about the fields they work in and how they got there. There will also be school talks throughout the day. The Monday, Tuesday and Friday will continue to be aimed at students aged 14 and above, and their teachers.

For more information: and booking, visit bit.ly/RSsse2019.

Physics education research

Conceptual change: more than replacement

This column, by James de Winter (the University of Uppsala and the University of Cambridge) and Richard Brock (King's College London), highlights accessible ways to bring physics education research into practice.



An example conceptual profile for heat, representing the multiple understandings of heat that a learner might possess and the likelihood of their activation.

Research suggests that students come to science lessons with ideas about the world that contrast with accepted scientific models. Teachers work to support students to transition from their initial ideas towards accepted scientific concepts, a process known as "conceptual change".

However, research also indicates that the process is more complex than simply replacing one concept with another.

Firstly, both novices and experts may possess multiple interpretations of the same concept: learners may believe that heat is both a substance-like entity that flows and an abstract concept.

Secondly, the activation of concepts can depend on the situation: even an experienced physicist may use a substance-like model of gravity in some contexts, albeit with an awareness of the limitations of that model.

Conceptual profiles

Eduardo Mortimer calls the set of different ways in which a concept is used across contexts a conceptual profile. As the activation of conceptions depends on the context, teachers should assess students' understanding in a range of contexts. For example, a student may correctly apply the scientific concept of heat to the context of conduction in an iron bar but, when questioned about a fire, assume that heat has the properties of a living thing.

Teachers should be cautious in assuming that a student has learned based on evidence from assessments in a small number of contexts. Rather than thinking of learning simply as the replacement of one concept with another, the process is better imagined as a gradual change to a learner's conceptual profile as the likelihood of the activation of different conceptions is altered.

- *Conceptual Profiles. A Theory of Teaching and Learning Scientific Concepts* (edited by Eduardo Mortimer and Charbel El-Hani) contains empirical studies describing the conceptual profiles of students across a range of science topics.

For more information on this model: and related ideas in the work of Linder and Taber visit the Physics Education Research (PER) group on TalkPhysics at talkphysics.org/groups/physics-education-research-per, or email us at PER@iop.org.

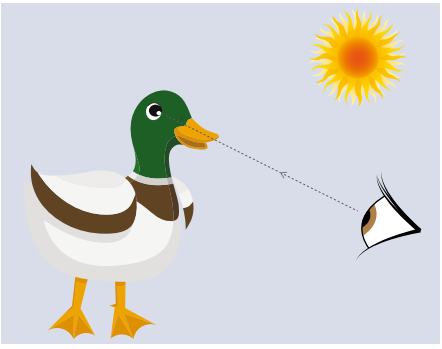
PIPER tackles preconceptions and misconceptions

Building on pupils' preconceptions is one of seven recommendations in the Education Endowment Foundation's recent report, *Improving Secondary Science*. We are now working on a suite of tools to enable physics teachers to do just that.

Practical Implications of Physics Education Research (PIPER) will form part of the IOP's major new website for teachers of physics, due to go live later this year. PIPER's new online resources will equip teachers with the means to understand, identify and then challenge misconceptions in the classroom. We have developed them in collaboration with researchers from University College London, the University of York and Canterbury College, Christchurch.

Understand

We've collected an extensive bank of common misconceptions to enable teachers to better understand the wide variety of ideas that children bring to the classroom. Grouped by topic and backed up by references from physics education literature, each one has been distilled down to a simple statement and contains links to academic studies that support its existence.



Common misconceptions: students may have a "naïve concept" that an image is a physical entity that the eye can pick up.

Identify

Where possible, we have linked each misconception statement to resources that teachers can use in the classroom to identify that misconception in their students. Currently, these are print-ready worksheets of diagnostic questions, but in the future, we plan to extend this to a wider range of resources.

Challenge

To help teachers challenge their students' misconceptions, we have provided links to teaching resources on the same topic from elsewhere on our new website. Of course, no single activity can be guaranteed to magically fix an erroneous idea, but they might help challenge a student's thinking.

We started out with two areas: "forces and motion" and "electricity and magnetism", and throughout 2019 we will be rolling out new content for other areas of the curriculum.

For more information: contact Alex at piper@iop.org. Watch out for more announcements on the new website later this year.

EVENTS FOR TEACHERS

Physics CPD Day
Clifton College, BS8 3HE
29 March
This full day of training and workshops is suitable for anyone involved in teaching physics. A keynote talk from Laura Nuttall will discuss gravitational waves and LIGO.
- For details and registration: bit.ly/TalkPhysicsBristol.

Teaching Motion (Kinematics)
Worcester University, WR2 6AJ
8 April
Forces, motion graphs and equations of motion with demonstrations and practicals, strategies to overcome misconceptions and teaching approaches.
- Book by emailing: nicky.thomas@iop.org.

Forces and Motion
Saffron Walden County High School, CB11 4UH
25 April
This session will explore ways of representing forces and how these lead to a clearer understanding of forces and their effect on motion. We will start with the main misconceptions and offer teaching approaches and ways to assess students' understanding of this conceptually difficult topic.
- Details and registration: bit.ly/TalkPhysicsForces.

Using Videos to Analyse Forces and Motion Practicals
Exeter Maths School, EX4 3PU
4 May
This event will demonstrate the use of video software to analyse practicals, including *g*, by freefall and conservation of momentum in one and two dimensions.
- Details and registration: events@exeterms.ac.uk.

Space, the Final Frontier!
Formby High School, L37 3HW
5 June
Despite the removal of a lot of content from the curriculum, there's still "space" to teach about space. Space can be an engaging context for curriculum content, and we'll cover cosmology in GCSE specs.
- Details and registration: bit.ly/TalkPhysicsFrontier.

IOP Physics Big Day Out
RAF Museum, Cosford
20 June
Booking details to follow.
- Further details: physicsiseasy@googlemail.com.

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

Stirling Meeting
Stirling Court Hotel, FK9 4LA
29 May
The 45th Annual Scottish Teacher meeting, "One Small Step for Physics", will celebrate 50 years since Apollo 11's Moon landing and 100 years since the eclipse where Eddington confirmed Einstein's General Relativity prediction of gravitational lensing.
- Details and registration: stirlingmeeting.org.

Rugby Meeting
Rugby School, CV22 5EH
5 June
The 31st Annual Meeting for Teachers of Physics in Schools and Colleges will feature workshops, an exhibition and keynote lectures from Michael de Podesta of the National Physical Laboratory and Rebecca Smethurst of the University of Oxford.
- For details and registration: iop.org/rugby.

2nd IOP North West Physics Teacher Network Conference
Daresbury Labs, WA4 4AD
27 June
A full day of training and workshops for anyone involved in teaching physics. It will feature workshops, a tour of the labs and a keynote speech by Tim O'Brien from Jodrell Bank.
- Details and registration: andrea.fesmer@talk21.com.

IOP/SPN South West Physics CPD Day 2019
Ivybridge Community College, PL21 0JA
2 July
The day includes a keynote from David Cotton on "Tones, Tings and Tines", networking opportunities, workshops and the popular "Have you ever shown them this?" carousel of ideas and demos.
- Register your interest: bit.ly/TalkPhysicsSWest.

Durham Teacher Day
Physics Department, Durham University
4 July
Booking details to follow.
- Further details: ruth.wiltsher@iop.org.

Annual SPN Physics Conference
Charterhouse School, GU7 2DE
6 July
A free day of varied physics CPD, including a keynote talk from Annela Seddon, a wide range of workshops, a supplier exhibition and a chance to network with colleagues from across the region.
- Register your interest: bit.ly/TPcharterhouse.

EVENTS FOR STUDENTS

Institute for Research in Schools (IRIS)
Various venues and dates
Presentations by leading physicists, IRIS and school students involved in research.
- Details and registration: info@researchinschools.org

Too Sensitive for Science? Emotion, the Secret Asset to Your Career
Bolton School Girls' Division, BL1 4PB
20 March
Touching on confidence issues, imposter syndrome, the fear of failure, unconscious bias and online misogyny, we will also dispel the stereotype of scientists as cold, unemotional and male.
- For details and registration: bickringill@boltonschool.org.

The Dark Side of the Universe
Bolton School Girls' Division, BL1 4PB
29 April
Pete Edwards, director of science outreach at Durham University, will reveal the nature of the dark stuff, explain how we know it is there and explore what it does.
- For further details and registration: bickringill@boltonschool.org.

Space School
School of Physical Sciences, University of Kent, CT2 7NH
2–4 August
This residential will present students aged 15 to 18 with the chance to take part in observing with telescopes (including the Beacon Observatory), designing and launching rockets and working on space-science projects.
- For details and registration: spaceschool@kent.ac.uk.

GRANTS

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 to 19. The deadlines for 2019 are 1 June and 1 November.
- To download an application form and for more information, visit: iop.org/schoolgrants.

physicsworld

Ellen Phillips, assistant editor of *Classroom Physics*, picks out stories from our magazine for the global physics community.

Whizz-bang science


Shutterstock

Fireworks have become a hallmark of celebrations around the world, but the black powder comprised of charcoal, sulphur and saltpetre, developed by the Tang Dynasty in the 9th century AD, still forms the basis of all fireworks today. This article looks beyond the bright colours and loud bangs, to explore the scientific methods that pyrotechnicians use to improve the safety, environmental impact and the spectacle of fireworks.

- In the December 2018 issue: bit.ly/PWFireworks.

Salt-free drinkable water comes at a cost

Across the world, some 16,000 desalination plants are busy purifying seawater and brackish aquifers to produce 95 million cubic metres of fresh, salt-free drinkable water every day. But there is a potentially polluting price to pay: for every litre of fresh water, the desalination plants produce around 1.5 litres of toxic brine. Now, a new study is urging nations to develop better solutions and new ways to exploit the minerals in the waste water in order to support efforts to advance the declared UN sustainable development goal of reliable, safe water on tap for everyone in the world.

- Full article at: bit.ly/PWDrinkingWater.

Semiconductors set to shape the future

Today, we drive cars that contain more computing power than the Apollo spacecraft that first landed men on the Moon in 1969. Desktop computers and laptops from only 20 years ago look positively Stone Age compared to today's tablets, smart watches and phones, given that so much electronics can be shoehorned into a tiny space. What can we expect in the years ahead? Will we no longer need to carry our electronic devices wherever we go? Will we be able to wear them in our clothes or graft them onto our skin instead? This article explores whether the answers will depend on continuing advances in semiconductors, those hybrid materials that incorporate features of both insulators and conductors.

- In the January 2019 issue: bit.ly/PWsemiconductors.

Our YouTube channel hosts videos from our events and lectures, interviews, physics demos and more. Subscribe at youtube.com/user/InstituteofPhysics.

Three-minute wonder of physics competition

Students who are currently making choices about their future careers may enjoy the videos of our recent 3 Minute Wonder (3MW) competition. Early-career researchers in physics-related fields (both industry and academia) from across the UK and Ireland competed to explain what they do in just three minutes.

The contestants may use one slide, one bespoke video and as many props as necessary to illustrate their work, and they are scored for physics content, presentation skill, level of engagement and entertainment value. Points were deducted if their presentations overran.

Fourteen videos in total were filmed in the famous Farady Lecture Theatre at The Royal Institution. They are great fun, ranging from finding "Dave" by looking around corners to revealing nature's worst-kept secret!

- Watch all the finalists at: bit.ly/YT3minute.

3D printing of jelly

PhD student Kate Oliver won the 3MW grand final for her talk on the 3D printing of jelly. Kate is finishing her PhD at the Bristol Centre for Functional Nanomaterials. She described her research into printing soft materials that can change shape, producing jelly-like objects that can shrink on heating. Explaining that this is important for making prosthetics that work well with the human body, Kate said, "Jelly is wobbly like we are wobbly".

- Watch at: bit.ly/3MWjelly.


IOP

Courtney wins audience award for 2D materials and metal: a necessary combination

The runner-up of 3MW, Eileen Courtney, spoke about solving the problem of how to protect 2D materials such as grapheme from nearby metals that interact and break the lattices. Eileen, a second-year PhD student at the University of Limerick, also won the audience award for her presentation. She said afterwards: "I'm shocked as I didn't expect to come over and actually win anything. I was just hoping to visit and see some of the physics being done elsewhere."

- Watch at bit.ly/3MWmetal.

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 Italian Job: an exercise in turning forces

Moments or turning forces can be difficult to make more interesting, especially for older students. Once the balancing toys are covered and the balancing beam games have been played, the teacher can be left with nothing much to generate interest. Mike Follows writes about a very enticing idea in *The Italian Job: an exercise in turning forces*. At the end of the film (*The Italian Job*), the robbers are left at one end of a coach with their loot at the other end while pivoting over a cliff edge. The challenge is to come up with a solution, and data is presented that allows many calculations to be carried out.

Physics Education

● By Mike Follows, who teaches physics at King Edward's School in Birmingham. He has a PhD in ultralow-temperature physics and enjoys teaching physics using unusual contexts: bit.ly/PEDmoments.

The recycling of myths

There is little point teaching something well if what you teach is wrong, so looking at the physics is a good starting point for planning any lesson. This also stops the recycling of myths. However, I doubt I would have spotted the errors in my thinking that are highlighted in this paper. The authors consider the well-known demonstration of friction by two interleaved books. They show that atmospheric pressure plays a significant role in this experiment, a factor that has not been part of the popular explanation, which is often attributed to friction alone.

● By Dragia Ivanov and Stefan Nikolov, Plovdiv University: bit.ly/PEDbooks.

Fundamental constants and SI base units

In November 2018, the General Conference on Weights and Measures voted to redefine the International System of Units, changing the world's definition of the kilogram, the ampere, the kelvin and the mole. The new definitions are coming into force on 20 May, so the cylinder of a platinum alloy stored in France that has defined the kilogram for more than 130 years (the International Prototype of the Kilogram) will be retired and replaced by the Planck constant. Give your A-level students a few paragraphs from this paper, which was written more than 40 years ago. It covers measurements of the base units and how they relate to the fundamental constants. Ask them to compare it with this contemporary National Physical Laboratory news story (bit.ly/PEDnpl) about the redefinition of base units.

● By B W Petley of the National Physical Laboratory: bit.ly/PEDnplsi.

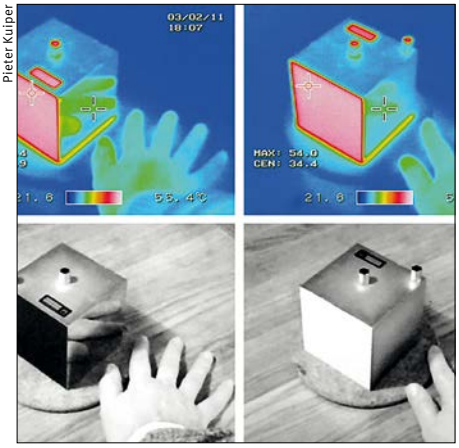
talkphysics

Caroline Davis, *Classroom Physics* editor, chooses some edited highlights from our online discussion forum.
Log in or register to join these discussions at talkphysics.org.

Leslie's cube

Sandy admits: "I have dodged the Leslie cube bullet up to now. On digging the stuff out and having a play around with it, the results I got are completely wrong. The white gloss surface emits by far the most radiation. After querying this with a colleague he said he gets the same results, so it would appear that something other than me is causing the problem." Sandy asks why this might be the case and how to get the apparatus to work properly. The discussion reveals a common mistake in textbooks: what might be true for visible light is not necessarily so for infrared radiation.

Pieter Kuiper



● Follow the discussion in the Teaching Physics 14–16 group at bit.ly/TPlesliecube.

First time teaching A-level physics

Daniel has just accepted a job that will require him to teach A-level physics for the first time and he's looking for suggested books and resources to improve his subject knowledge. Lots of members offered suggestions, including, of course, IOP's Teaching Advanced Physics resources, and plenty more besides. Sandy offered this advice: "Above all, ask those around you – do not suffer in silence!"

● Follow the discussion in the Teaching Physics 16–19 group at bit.ly/TPfirstalevel.

Why are the products of α and β emission not ions?

Dom S asks this question as he prepares for his teacher training. David replies, "Beta decay does produce ions. The W+ carries away the positive charge of the proton, so the proton becomes a neutral neutron and the W+ decays into a beta plus particle and an electron neutrino. So the number of positively charged particles remains the same as the number of negatively charged particles in the universe." Steve adds, "David is of course right, but the question my students always ask is why, when writing out a nuclear decay equation, don't we worry about indicating the charge on the decay products? The answer I always give is that we just don't care! The decay will take place as written even if the parent is completely ionised – all of its electrons stripped off – so its charge just doesn't matter."

● Follow the discussion in the Teaching Physics 16–19 group at bit.ly/TPions.

Stories about physics

The Sun: late rising, twilight and a lady computer

Due to refraction of light by the atmosphere, the Sun appears to rise before it crosses the horizon. A Dutch explorer, Gerrit de Veer, first recorded the phenomenon on an expedition to find a northeast passage to China. He reported that during the polar winter the Sun was visible two weeks before calculations suggested it should return. Sunset and sunrise are defined as the times at which the upper limb of the Sun contacts with a horizon of 0°. The non-uniform density of the atmosphere causes the Sun's rays to follow curved paths so that the Sun's apparent position differs from its true location. Observations made from Edmonton, Alberta, suggest an average refraction of 0°.7, though the size of the effect depends on a number of factors, including the temperature of the atmosphere. The phenomenon is sometimes referred to as the Novaya Zemlya effect and, in extreme cases, for example on 10 January 1991, sunrise can appear to occur as much as 12 minutes before the Sun actually crosses the horizon.

Types of twilight

Once the Sun has passed below the horizon, the atmosphere continues to be illuminated by the scattering of light in the atmosphere.

Shutterstock

The Sun often appears to rise before it has even passed the horizon.

The twilight period is divided into three categories: civil twilight is the interval between sunset and the time the Sun is 6° below the horizon; nautical twilight occurs when the Sun is between 6° and 12° below the horizon; and astronomical twilight is the period when the Sun is between 12° and 18° below the horizon. As the sky remains illuminated during civil and nautical twilight, astronomers often use red lights that maintain the dark adaptation of the eyes once astronomical twilight begins.

A pioneering female astronomer

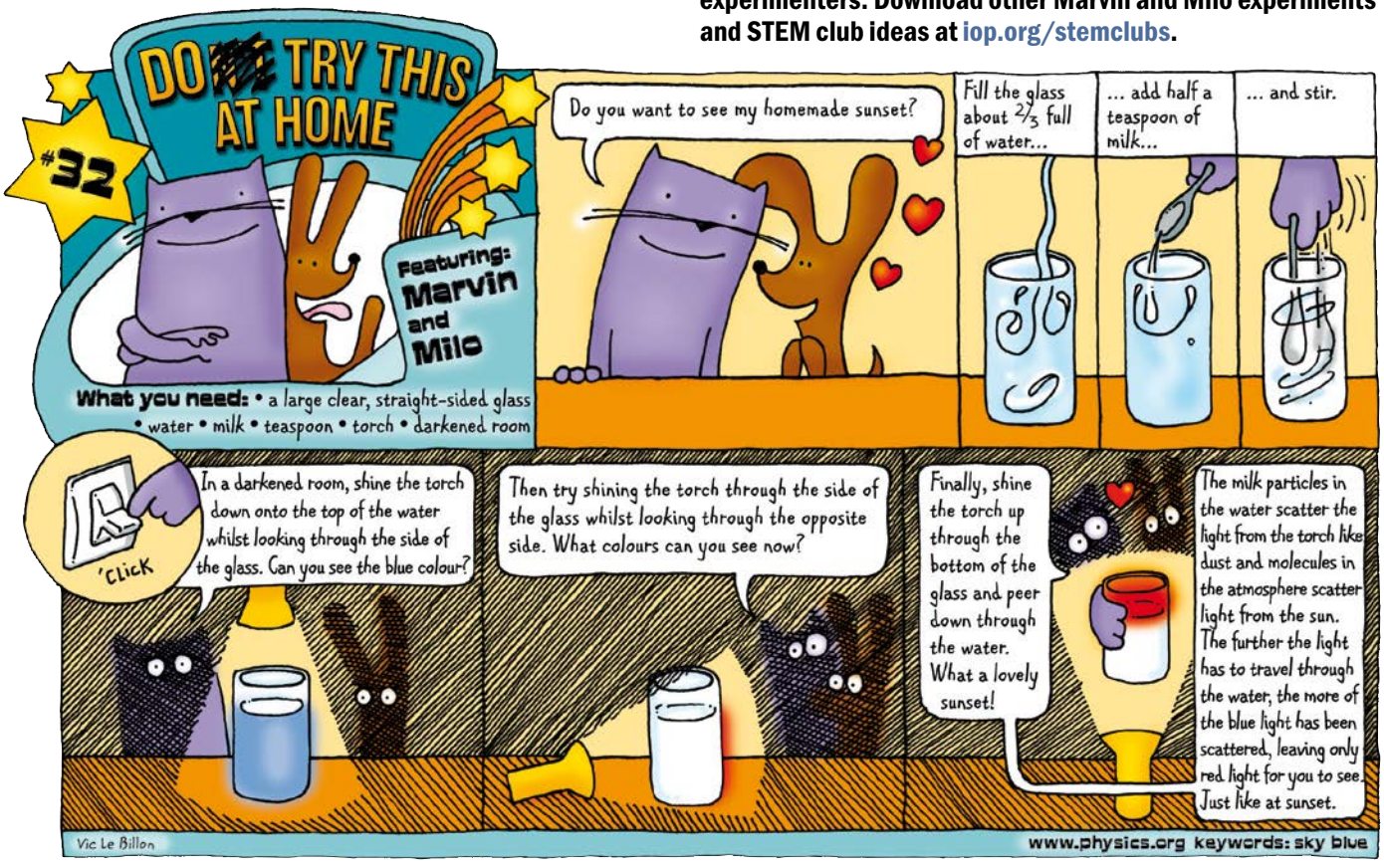
Annie Maunder made significant contributions to the study of the Sun. Ineligible for a degree, in 1889 Maunder was the highest ranked mathematician in her year at Girton College Cambridge, and went on to work as a "lady computer" at the Royal Observatory, Greenwich. There, she devoted her time to photographing the Sun and tracking sunspot activity, contributing to the development of the "butterfly diagram" of sunspot movements. Following her marriage to Walter Maunder, she was forced to curtail her research due to expectations on married women at the time. Undeterred, she obtained a grant to buy her own camera and took part in several overseas expeditions, photographing eclipses and the solar corona. She published her research and co-authored a popular book on astronomy with her husband, though Walter observed that the text was "almost wholly the work of my wife".

For more information: follow Richard Brock's (King's College London) stories about physics on Twitter @RBrockPhysics or join the discussion at talkphysics.org/groups/stories-about-physics.

Marvin and Milo

Homemade sunset

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.



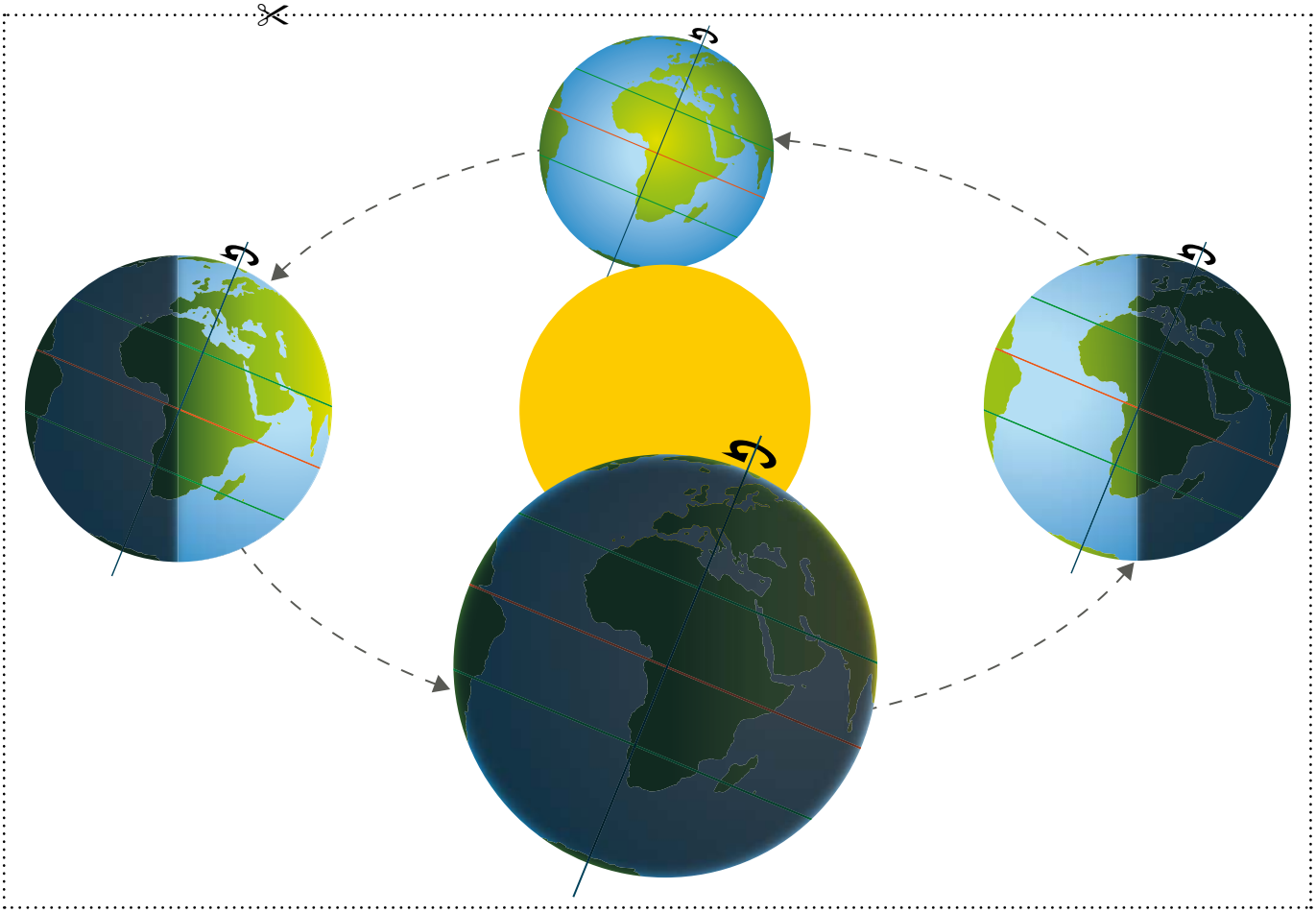
Seasons: solstices and equinoxes

The day on which a season starts is either a solstice or an equinox. A solstice is the longest or shortest day of the year. On an equinox, the day and night last equal times.

Instructions

Cut out the diagram and the labels below. Place the labels on or next to the diagram at one of the four positions of the Earth. Get your answers checked and stick the diagram and labels into your book.

Diagram



Labels

Solstice	**March**	**Longest day of year in northern hemisphere**	**Start of summer in UK and Ireland**
Solstice	**June**	**Shortest day of year in northern hemisphere**	**Start of autumn in UK and Ireland**
Equinox	**September**	**Longest day of year in southern hemisphere**	**Start of winter in UK and Ireland**
Equinox	**December**	**Shortest day of year in southern hemisphere**	**Start of spring in UK and Ireland**

Skydomes and seasons

This activity uses a globe with a transparent dome to explore why day length and the path of the Sun across the sky varies with the seasons by comparing the March equinox and June solstice. The accompanying worksheet is on page 11.

Equipment required for demonstration (or per group of students)

This activity works best in a darkened room. You will need:

- Approx. 40 cm diameter globe
- Small transparent dome (eg half of a 4 cm clear plastic bauble)
- Lamp
- Blu Tack or sticky tape

Activity

1. Attach the dome to the globe, covering the UK and Ireland.
2. Hold the globe about 1 m from the lamp (the Sun) so that the globe's equator and the centre of the lamp are at similar heights.
3. Estimate day length on the March equinox: (a) tilt the globe so that the North Pole points away from the direction of travel (see A on diagram); (b) spin the globe anticlockwise about its axis until the reflection of the lamp just appears on the base of the eastern edge of the dome. This is the sunrise position; (c) continue to spin the globe so that the Sun travels up the dome and sets on its western edge. Estimate the angle that the globe rotated through from sunrise to sunset.
4. Estimate day length on the June solstice: (a) move the Earth to its position three months later by walking a quarter of a circle anticlockwise around the lamp. The axis should now point towards the lamp; (b) put the globe in the sunrise position (see B on diagram). Spin it anticlockwise and estimate the angle that it rotated through from sunrise to sunset.

Discussion

- Students should see that on the March equinox, a day corresponds to half a rotation of the globe, ie day length is 12 hours. On the June solstice it requires more than half a rotation, ie day length is greater than 12 hours.
- They should also see that on the March equinox the Sun rises in the east and sets in the west, while on a June solstice, it rises in the northeast, travels higher across the sky and sets in the northwest.
- Ask your students to think about how the seasons coincide with day length. It is warmer in June because the days are longer (and also because the angle of the sunlight is steeper). But summer only begins after the June solstice because the longest day is not the warmest; it takes a while for the atmosphere to warm up. In fact, July and August are the warmest months in the UK and Ireland.

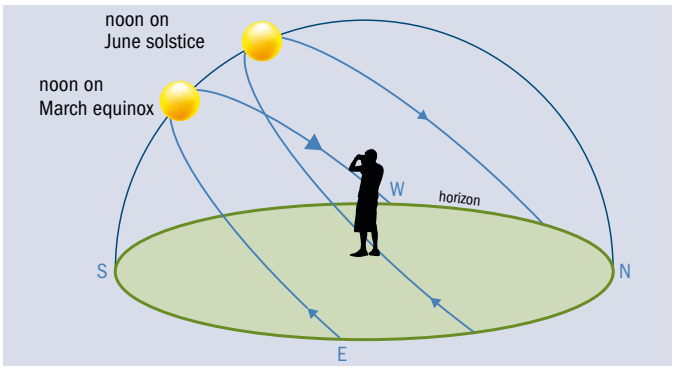
Equinox: the date on which day and night last equal times across the world. Equinoxes occur in March and September, when the Earth's tilt is aligned to its direction of travel. The March equinox marks the first day of spring in the northern hemisphere and the first day of autumn in the southern hemisphere.

Solstice: the longest day of the year in one hemisphere, and the shortest in the other. Solstices occur in June and December when the Earth has its maximum tilt towards/away from the Sun. The June solstice is the first day of summer in the northern hemisphere and the first day of winter in the southern hemisphere.

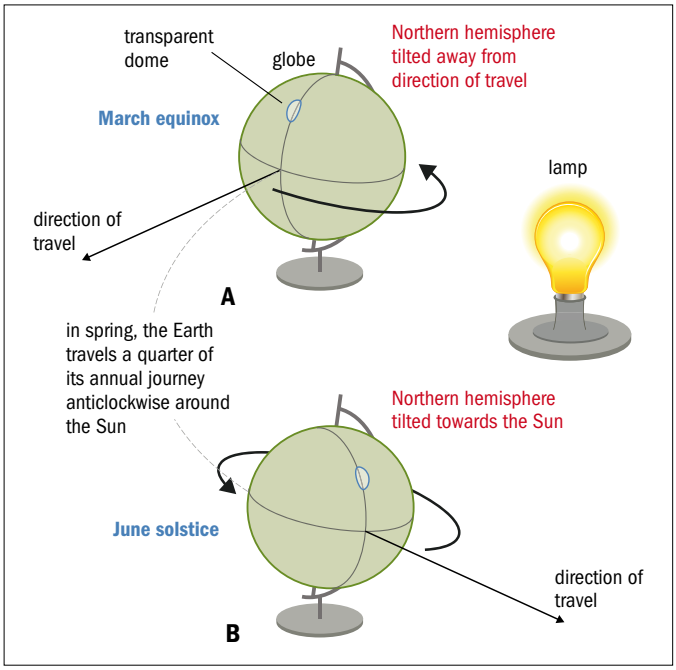
The Sun's position at noon on the March equinox.

Dates for 2019

Spring in the UK and Ireland starts on the equinox of 20 March. Summer starts on the solstice of 21 June.



This sun path diagram shows the apparent path of the Sun across the sky. Link this to the activity by asking students to imagine what they'd see if they were inside the dome on the globe on the March equinox and the June solstice.



Sunrise position for (A) the March equinox and (B) the June solstice.

For a demonstration: of how the surface temperature of the Earth varies according to the angle of sunlight, see bit.ly/SeasonsVideo2. Students can explore day, night and seasons on other planets in activity five of Exoplanet Physics at iop.org/exoplanets.

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