March 2022 | Issue 60

Classroom physics

The magazine for IOP affiliated schools

Getting the seasons in order

iop.org

IOP Institute of Physics

This issue

Credit: Maderla/Shutterstock

Correcting the seasoning

The most common reason students (wrongly) give for why it gets warmer as we move into spring and summer is the Earth getting closer to the Sun. And all too often, this misconception endures into adulthood – just ask around the staffroom.

As we in the northern hemisphere leave winter for hopefully more clement weather, this is a great opportunity to remind students what is actually happening. The Sun is higher in the sky and so its radiation is less spread out when it hits the ground and it warms it more strongly. Meanwhile, days are getting longer so the ground is warmed for more time. Overall, more radiation from the Sun is absorbed per square metre of ground.

So this edition of Classroom Physics focuses on the seasons. Our central pull-out (pages 9-12) is a sequence of practical activities designed to help build students' understanding of how the seasons actually come about.

This is crucial, not only for exams, but also because we are going to see more extremes in our weather (see feature on page 7) and will need to find ways to prepare for and tackle the effects of climate change (see careers case study on page 6).

Of course, it's not just the Earth which experiences seasons. Uranus has 20-year-long seasons but Mercury has none (see Stories from Physics page 13).

Finally, there are two important calls to action for teachers in this edition: firstly, if you haven't already, add your name to the Limit Less campaign and ask someone from your SLT to add your school's support too (see page 3). Secondly, you will soon receive a request to fill in what we hope will be the largest survey of science teachers in a generation (see page 5) – your answers will be vital to ensuring our students have the workforce they deserve.

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Classroom Physics editor

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Front cover image credit
Science and Technology Facilities Council

With this issue...

Posters

IOP Affiliated Schools and Colleges will receive our poster about exoplanets (see page 11) and a careers poster from the Inventive Podcast (see page 18)

Follow the IOP Education Department on Twitter **@IOPTeaching**

Read Classroom Physics online and access previous editions at **spark.iop.org/classroom-physics**

IOP pillars of the community

You may have begun to notice changes to the way the IOP is operating, especially in our support for physics teaching and learning. Charles Tracy, IOP Senior Adviser, Learning and Skills, describes how a dual approach is addressing familiar challenges in new and innovative ways

The IOP is now moving wholeheartedly into implementing activities to support our current strategy. Our work with teachers and students in schools and colleges is built on two mutually supportive pillars:

- doing all we can to make sure that no student feels excluded from physics and that all students feel that they can take an interest in the discipline and consider a future working in it

- ensuring that any seed of interest that they have lands on fertile ground in school and that they all have access to a world class education in physics.

The first pillar mainly comprises our Limit Less campaign which is designed to influence policy-makers, senior leaders and anyone who themselves influences young people. As well as trying to drive systemic change, the campaign will change attitudes to physics and debunk a number of misconceptions and myths about the discipline – such as that it is difficult, boring or the preserve of certain exclusive groups. We want young people to see physics as accessible, creative and inclusive. The campaign will break down the barriers above and reduce damaging expectations that navigate some groups of students away from physics.

This work is quite new and, as such, is a little experimental and quite thrilling. We recently launched a TikTok initiative which is well on its way to getting a million views. And we are currently asking teachers and secondary school leaders to sign up in support of our manifesto – to give us weight and influence with governments (please do sign up via the link below and encourage someone in your SLT to do the same on behalf of your school).

The second pillar will be more familiar to you – though we are shifting slightly in the way we build it. Our desire is to ensure that all students have a world class experience of physics through excellent teaching of a great curriculum. This is part of a programme to improve the whole ecosystem of physics, in particular to make it more inclusive.

With the current shortage of in-field physics teachers, we therefore have our work cut out – to increase their number and to support those who are teaching physics out-of-field. To increase numbers, we will have three strands of activity: recruitment, retention and retraining. In part, this will be working with policy-makers but we will continue to pilot or manage specific interventions to increase recruitment and reduce attrition. We are also planning and advocating for a ramping up of in-service retraining courses to address the acute need for physics teachers in schools that currently have none.

As part of this work, and to align with our role as a professional body for physics, we will increase our focus on building a community of physics teaching – bringing people together, hosting events and providing means of on-line support. Whilst we will no longer be running major government CPD programmes, it is our intention, as outlined in our Subjects Matter report of 2020, to underpin and assure programmes that do exist and to improve the ease with which teachers can choose and access professional learning in physics.

IOP TikTok eggs-citement

Credit: tamzintaber

The egg challenge was the first Limit Less campaign activity on TikTok. Its objective is simply to share the message that "physics is for everyone' with the young TikTok audience to provide the foundation for more activity throughout 2022. Follow our TikTok videos using **#IOPlimitless**

more...

The IOP's strategy for 2020-24
iop.org/strategy

Explore the Limit Less campaign
iop.org/LimitLess

Follow the TikTok initiative
tiktok.com/tag/ioplimitless

The Subjects Matter report
iop.org/subjects-matter

Limit Less

Demand better for young people

Sign our manifesto for change - and ask your SLT to do the same

campaign.iop.org/manifesto

Credit: IOP

IOP coaches who have recorded videos for early career teachers include (top l-r) Saša Harper and Carole Kenrick (bottom l-r) Mark Whalley, Daisy Fox and James de Winter of the University of Cambridge

CPD videos for early career teachers

We have launched a library of short videos for early career teachers (ECTs). Focusing on physics pedagogy, the videos give practical suggestions on how to address some of the challenges ECTs might encounter in their first years of teaching physics.

New teachers have varying levels of access to support from experienced physics teachers during their early teaching careers, indeed some find they are the only specialist physics teacher in school. This library makes a common base of knowledge widely available to all physics ECTs. The aim is to help build competence and confidence early in a teacher's career, qualities which we know are strongly linked to job satisfaction and teacher retention.

The most recent videos to be added address teaching practical physics and are written and presented by James de Winter, PGCE physics tutor and associate lecturer at the University of Cambridge. These videos, and the associated discussions with their mentors, have been highly anticipated by ECTs who have felt the lack of experience in teaching practical work during their training years.

Also popular with ECTs are the three videos which address how to approach teaching elements of maths in physics. The recordings also highlight the importance of working with colleagues in the maths department to understand how certain mathematical concepts are taught in school.

True to the IOP's commitment to inclusion and diversity, we have a set of videos covering the concepts of science capital, increasing participation in physics and how to ensure physics teaching is inclusive and relevant to students.

The library of videos is a key element of the Early Career Professional Learning programme which supports the IOP's commitment to subject-specific CPD for ECTs. The programme, joint-funded with the Gatsby Foundation, is a pilot project investigating how best to add subject-specific support to the Early Career Framework.

more…

The full library is available at **spark.iop.org/early-career-teaching-cpd-videos**.

Find out about the ECPL programme and IOP support for physics ECTs at **iop.org/ecpl**.

The Great Science Teaching Survey

Do you know how many specialist physics teachers there are in your region? How many teach more chemistry than physics? Do teachers of combined science feel confident teaching physics?

In most parts of the UK and Ireland, this information is not captured by workforce surveys and therefore not available to policy makers. This month, we're launching a collaborative project to change that.

We are inviting all science teachers, heads of department and technicians in secondary schools in the UK and Ireland to take part in a major survey during March 2022. Keep an eye on email and social media for your invitation to participate.

The IOP has an ambitious strategy to transform the physics landscape for the UK and Ireland and ensure a thriving physics ecosystem. The seeds for this system are sown in school. Therefore, as part of this activity, we are working with the Royal Society of Chemistry, in cooperation with the Royal Society of Biology, on a major new joint project to build a robust and detailed evidence base of the science teaching landscape. This will inform our work in order to better represent and support teachers and technicians. We anticipate that this will become an annual survey, with this first year providing the baseline.

Shift Learning have been contracted to conduct this research programme on behalf of the three learned societies. Research outcomes will be used to inform policy recommendations and shared with the science-teaching communities.

IOP Institute of Physics

Royal Society of Biology

ROYAL SOCIETY OF CHEMISTRY

more…

Access the survey at **iop.org/WeTeachScience**

IOP calls for investment in physics skills to support economic recovery

An Institute of Physics commissioned report has revealed that as we enter a new economic era post-Covid and post-Brexit, recovery and growth in the UK and Ireland economies will be severely limited without greater investment in the development of physics skills.

The report reveals that physics skills already support nearly 2 million or 1 in 20 jobs across the UK and Ireland, and employer demand is strong and growing. Yet the IOP says that without concerted action the existing shortfall in physics skills is only set to worsen, limiting the extent to which the two countries can take advantage of new economic and technological developments. It will also limit the role they can play in the transition to a net-zero world and new green economies.

The report concludes that because of its crucial role in driving innovation, "strengthening the provision of physics is central to the ambitions to improve economic growth, prosperity and living standards".

The IOP is calling for action by:

- Addressing shortages of specialist physics teachers
- Challenging misconceptions about physics and the jobs it provides access to
- Ensuring availability of a variety of physics education and training pathways
- Incentivising employers to invest in employees' upskilling and reskilling
- Ensuring interventions aimed at strengthening provision of physics skills move beyond the level of 'STEM skills', given the distinct labour market demand for physics.

Tony McBride, IOP Director of Policy and Public Affairs, said: "This report shows clearly that we need more young people to fulfil their potential by doing physics, no matter their background or where they live."

The IOP asked labour market analytics firm Emsi Burning Glass to evaluate the scale of the physics-related job market, how physics skills are used across occupations, industries and regions, and levels of demand for physics skills at all levels.

more...

Download the report at **iop.org/strategy/productivity-programme/workforce-skills-project**

A scientific journey into the past

Vasileios Spathopoulos, of Glasgow International College, used an IOP Anthony Waterhouse fellowship to fulfil an idea that had been developing for a while: to combine his interests in astronomy and history to create shareable classroom resources. Here's what he did...

My idea was to create activities that would simulate the astronomical observations and measurements of ancient and medieval cultures. To do this, I used the wonderful freeware Stellarium planetarium software. Anyone can download it (or even use the simpler, web-based version), to view a realistic representation of the sky from any location, at any time in the past, present or future. The fellowship provided me with the opportunity to research this field in my spare time and I eventually produced a total of 14 activities.

The ancient Greeks are often looked upon as the pioneers in this field but my intention was to portray the contribution of various civilisations and especially those non-western ones, whose contribution to the development of science is often not emphasised enough. Those completing the activities will thus follow in the footsteps of ancient Babylonians and Greeks, medieval Arabs and Chinese and Indian astronomers.

For example, in 190 BCE there was a solar eclipse visible from the ancient city of Alexandria in Egypt. The great astronomer Hipparchus used recorded measurements from this eclipse to estimate the distance to the Moon. By travelling back in time with Stellarium, you can view this exact same eclipse from Alexandria and estimate how far the Moon is from our planet.

Credit: Ala ad-Din Mansur-Shirazi, Public domain, via Wikimedia Commons

Islamic Astronomers at Work between circa 1574 and 1595

more...

Dowload the resources at **spark.iop.org/scientific-journey-past**

Papers about the resources in *Physics Education* at **bit.ly/PEDvas1** and **bit.ly/PEDvas2**

Vasileios is offering free workshops to schools - contact **vspathop@gmail.com**

The meteorologist who is always a student

Emily Gleeson is a research meteorologist with the Irish Meteorological Service, Met Éireann. She works on the physics developments in the HARMONIE-AROME numerical weather prediction model.

Can you tell us what first got you interested in physics?

Learning science in secondary school! I always liked maths and then got into science and physics. The school I went to had great labs and all the equipment. My teachers definitely inspired me to study science.

How did you get into your current job?

After a degree in physics and chemistry from Maynooth University, I did a PhD in physics where I specialised in submillimeter astronomy. I worked on a project that involved designing radiation detectors for the European Space Agency Planck Surveyor satellite, which measured remnant radiation from the Big Bang. Another PhD student told me about jobs in Met Éireann and I love extreme weather, so I applied. And here I am!

Do you still use the physics you learned in school?

Of course! Physics is problem solving, so the methods can be applied to any scientific or technical task. I now lead a team in Europe who develop the physics of the weather model that we use for operational weather forecasting. I specialise in solar radiation, radiation-aerosol interactions and surface physiography – so both surface and upper-air physics. My job requires lots of different skills. Problem solving, definitely. But also communication, adaptability, teamwork and patience.

I thought my PhD would be the end of my formal education but it's true that you're always a student! When I started working as a meteorologist with Met Éireann, I also studied for a masters degree in meteorology and more recently, I completed a diploma in statistics.

This month, we're talking about the seasons. Can you tell us how the weather events you work with are affected by the seasons?

The dominant influence on the climate here in Ireland is the Atlantic Ocean. Consequently, Ireland does not suffer from the extremes of temperature experienced by many other countries at similar latitude. Winters tend to be cool and windy, while summers, when the storm track is further north and depressions less deep, are mostly mild and less windy.

What do you like best about your role?

I love my job because it's also my hobby. Every day is different and there are so many different aspects to the job and so many opportunities within the organisation! I work with lots of fantastic people in Ireland and all over Europe.

Do you have any advice for someone who's considering studying physics?

To steal a line from Dr Seuss, you can steer yourself in any direction you choose! I've gone from submillimeter astronomy, to engineering in Intel, to weather forecasting, to climate change modelling, to short range numerical weather prediction model development. There are so many different paths.

more...
Find out more about Met Éireann at **met.ie/science**

Credit: Emily Gleeson

Emily enjoys hiking – this picture shows her with the Brocken Spectre phenomenon, a large shadow of an observer cast onto cloud or mist.

Order our new careers booklets!

Emily is just one of the many different people doing different jobs who we spoke to. They all have one thing in common - they studied physics at 16.

To receive our **Change the world: jobs that make a difference booklets** email **campaign@iop.org**. We have two versions: *UK & Ireland* and *Ireland & Northern Ireland.*

Part of the IOP's Limit Less campaign. For more information, visit campaign **iop.org/LimitLess.**

Extreme seasons

Seasons in the UK and Ireland have always been stable and mild compared to many parts of the world. Is climate change transforming the outlook?

Last year, dust storms ravaged China, cyclones tore through Fiji, mainland Europe and India experienced catastrophic flooding whilst an extreme heatwave across western North America sparked droughts and wildfires.

Extreme weather events like these are becoming more frequent and more intense. Human-caused climate change is now accepted as the most likely cause, but students may ask: what of the natural ebb and flow of our climate? The Earth has gone through multiple Ice Ages in the past – could we just be heading into the other natural extreme?

Earth's long-term climate is driven primarily by Milankovitch cycles. These determine the amount of solar radiation absorbed by Earth and are driven by the shape of Earth's orbit (eccentricity), the tilt of Earth's axis with respect to its orbital plane (obliquity) and the wobble of Earth's axis of rotation (precession). The obliquity cycle gives us seasons – the more extreme the tilt, the more extreme the seasons we get. The more extreme the seasons at the poles, the more likely any ice which forms in the winter is to melt in the summer. If polar ice doesn't persist through the year, then we can't cool into a glacial period. The eccentricity cycle can have a similar effect, controlling how close the Sun and Earth are at differing times of the year.

But Milankovitch cycles lead to changes in our climate over tens of thousands to hundreds of thousands of years. They cannot account for the current period of accelerated warming Earth has experienced since the Industrial Revolution (1.19 ˚C).

Over the past 60 years, physicists have refined computer simulations of the Earth's climate to understand this rapid and continuing change. From this, a clear cause has emerged: carbon dioxide. Doubling carbon dioxide in any of these simulations leads to a 2.5–4 °C global temperature increase. More difficult has been teasing apart whether rising levels of carbon dioxide are due to natural changes (like volcanic activity) or human actions. To extract the 'fingerprints' of climate change, many theories, observations and simulations have been used with sobering results. We now know humanity's emissions are having a significant impact on the world's climate. But does this explain the extreme weather we are witnessing? Can the relatively slowly changing patterns of weather in an area (climate) affect the ferocity of specific events (weather), from hot days to hurricanes?

Credit: eyematter/Shutterstock

Sandbags put down to protect a property in Sussex from flooding due to a tidal storm surge after Storm Eunice in February 2022

Attribution studies aim to answer this question. They feed a wide range of data and observations into two different computer simulations: one simulating the climate as it is today, and another simulating the climate as it would have been before the Industrial Revolution. Comparing the models lets researchers see the effect climate change had on a weather event.

For example, one study looked at the 2019 European heatwave, which saw a record 38.725 °C recorded in Cambridge. The researchers concluded that climate change made the heatwave about 10 times more likely, causing temperatures 1.5–3°C higher than they would have been without human influence.

Attribution studies also help shape our understanding of climate change and its impacts more generally. The planet warming up means more record-breaking hot days in more places. Higher temperatures lead to drier conditions, with moisture evaporating from water bodies and soil, leading to drought. This enhanced evaporation drives a more active water cycle: in the summer, more active thunderstorms can lead to flash floods when rain falls on dry ground whilst drought-stricken areas lose out on evaporative cooling, effectively making hot spells even hotter.

How does all this affect us? In summer (June–August), we should expect more hotter, drier weather with flash flooding and extreme summer heat. Warmer, wetter winters will be generally stormier, with depressions (low pressure weather systems) bringing heavier rainfall. Through continuing attribution studies of weather events and more sophisticated climate simulations, physicists will be able to better project future changes to our seasons and weather, helping us adapt to our changing weather - as well as motivating us to reach net zero faster.

Dr Benjamin Skuse
Freelance science writer

more...

2021 Nobel Prize-winning climate science pioneers Syukuro Manabe and Klaus Hasselmann **nobelprize.org/prizes/physics/2021/popular-information**

Climate-extreme weather interactive **bit.ly/CPclimatemapped**

Accessible introduction to attribution studies **bit.ly/CPattribution**

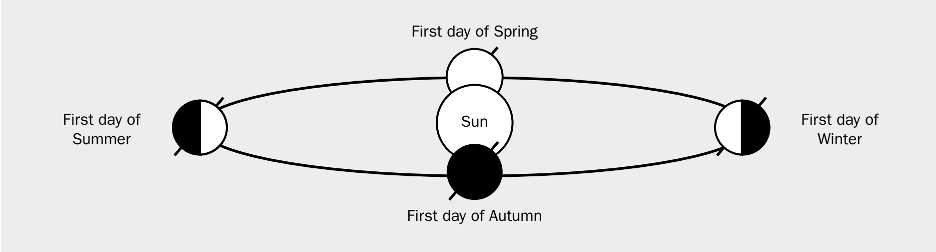
A career in severe-weather research **physicsworld.com/a/riding-the-storm-out**

NASA Milankovitch cycles resources **go.nasa.gov/3JHolor**

Physics education research

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.

Get involved with physics education research discussions by joining the **Physics Education Research** group on Talk Physics at **talkphysics.org/groups/physics-education-research-per** or email **research@teachphysics.co.uk**



This diagram, by comparison with some alternatives, caused significant improvements in students' explanations for the seasons

Teaching the seasons: the role of diagrams

An aspect of thinking like a physicist is the ability to interpret visualisations of phenomena. Diagrams are therefore a common feature of the physics classroom. If you are anything like us, you are likely to have favourite figures that you feel convey a context particularly effectively. Tools like Google Images make a range of similar, but subtly different, diagrams readily accessible.

When choosing a diagram, it is worth considering how its features might affect how your students learn. Teaching the origin of the Earth's seasons is a context in which diagrams can support students' understanding and teachers might reflect carefully on the form of image they use.

A study by Victor Lee, of Utah State University, reports the impact of making small changes to diagrams of the Earth's orbit on students' conceptions of the seasons. Lee recruited 652 students aged 14-15 and asked them to complete the sentences: 'It is warmer in the summer because...' and 'It is cooler in winter because...' The students then looked at one of six versions of an orbital diagram and repeated the explanation task. The six diagrams varied on whether the Earth's orbit was represented as a circle or as an ellipse, the perspective of the view (overhead or slanting), if the axial tilt was highlighted using a line, and whether coloured shading was applied to highlight day and night.

In the initial explanation, around 45% of the participants gave a scientifically correct response related to axial tilt. A further 15% gave explanations based on the location of the Earth in its orbit and 23% of explanations were based on the Earth-Sun distance. After viewing the diagrams, the total number of students producing axial-tilt explanations remained roughly constant. An unsurprising finding from such a brief and low intensity intervention.

The results did however reveal several interesting findings. First, no difference was caused by exposure to circular or elliptical orbital diagrams. Second, Lee found that one diagram in particular (above) - depicting an elliptical orbit with shading to indicate night and day and highlighting the Earth's axial tilt – produced more scientifically correct explanations.

Lee notes that shading areas of light and dark on the Earth appears to cue the use of side-based explanations, which link the origin of the seasons to the location of the Earth in its orbit. However, this effect seems to be mitigated by the perspective view of the solar system shown above, where the viewing angle appears to be tilted. This presentation seems to emphasise a focus on axial tilt. The sample size of the study raises caveats about the potential generalisability of the findings.

Beyond the findings for the context of teaching the seasons, the study illustrates how pedagogic decisions about apparently minor details, such as the shading or labelling of a diagram, can have significant consequences for learning. It is worth reflecting on theassumptions you make when planning, evenat a fine-grained level of detail. Why this image rather than an alternative? What is the clearest wording of this explanation? How might this demonstration be most effectively set up? A joy of physics teaching is that, even for expert teachers, there are always incremental changes to be made to hone your practice.

more...

The paper How different variants of orbit diagrams influence student explanations of the seasons can be downloaded at **digitalcommons.usu.edu/itls_facpub/135**

Pull out and keep!

Teaching 11 - 14

Seasons

Inside this pull-out:

- **Demonstration A: Thermochromic globe**
- **Demonstration B: Skydome**
- **Activity 1:** Spreading sunlight
- **Activity 2:** Seasons on exoplanets
- **Activity sheet:** Seasons on exoplanets

Getting the seasons in order

Many misconceptions about seasons persist into adulthood. Beliefs such as that the Sun is further away in winter are particularly enduring.

Understanding why its warmer in summer is conceptually challenging. An explanation requires three-dimensional thinking and an appreciation of interplanetary scales. A world globe and torch are very useful tools when teaching this topic to show how a spinning Earth around a tilted axis combined with motion around the Sun causes our annual seasonal variations.

Some students mix up cause and effect, thinking that somehow changes in plants cause seasons. Others think clouds are responsible. The most common misconception is that winter is caused by the Sun being further away from the Earth at this time of year. Related to this is the idea that it is the same season everywhere on the planet at the same time.

These misunderstandings can persist even for those that have visited countries south of the equator because land masses in the southern hemisphere tend to be nearer the equator than those in the northern. The temperatures when they arrive in winter may be similar to those they left behind in the UK summer. Before teaching this topic, you may want to get your students to research temperatures of countries in the southern hemisphere in different months of the year and compare them to those in the northern hemisphere. That should help reveal, for example, why Australians spend their Christmases on the beach.

Many students also do not realise that the Sun's path across the sky changes throughout the year. So you may want to discuss how shadows are shorter in spring and summer to help them see that the Sun follows a higher path across our sky in the warmer months.

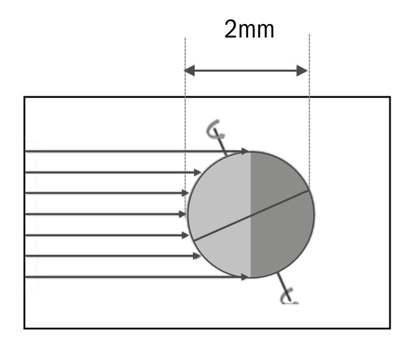
Diagrams in books can also be a source of confusion. For example, ray diagrams showing the Earth can give the impression that seasons are caused by the equator being close to the Sun. Use scale models of the solar system to help students appreciate that the difference in distance is not significant.

This pull-out contains a sequence of practical ideas to help build students' understanding of the two reasons it is warmer in summer:

1. The sunlight strikes the ground at a steeper angle and so is spread out over a smaller area
2. Days are longer and so the part of the Earth you are located at is warmed for longer.

Seasons to scale

If the Sun were a football 23 metres away, the Earth would be a small ball of Blu-Tack only 2 mm across. On this scale the equator is less than 1 mm closer to the Sun than the UK.



more...

We recommend diagnostic questions to check understanding from the Best Evidence Science Teaching resource produced by the University of York Science Education Group available at:
spark.iop.org/seasons-questions

Visit our misconception page on **spark.iop.org/most-students-think-it-cold-winter-because-sun-further-away-earth**

Demonstration A: Thermochromic globe

This demonstration shows that the reason for the variation in temperatures in the UK is the tilt of the Earth's axis.

Equipment

- World globe
- Filament lamp (or electric heater)
- Self-adhesive thermochromic plastic

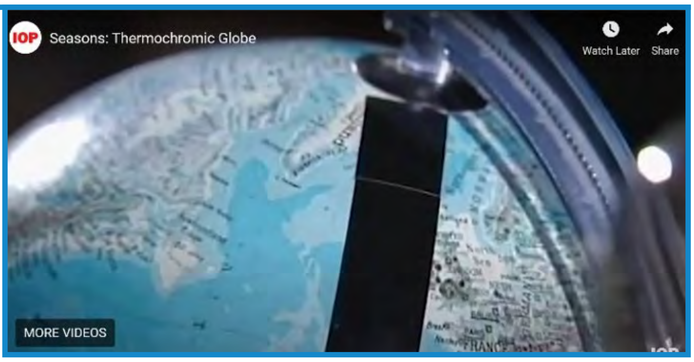
Procedure

1. Cut the thermochromic plastic into a strip and place it vertically on the globe next to the UK. Set the lamp-globe distance to ensure the thermochromic plastic strip shows a range of colours.

2. Rotate the base of the globe so that the northern hemisphere is tilted directly towards the lamp (summer in the UK).

3. Switch on the lamp and highlight the changing colours of the thermochromic plastic (counter-intuitively, lower temperature is indicated by red and higher by blue).

4. Switch off the lamp and rotate the base of the globe so the northern hemisphere is tilted directly away from the lamp (winter in the UK). Emphasise that you have not changed the lamp-globe distance.



Thermochromic plastic attached to a globe to demonstrate seasons

5. Switch the lamp back on.

Teachers' notes

Emphasise that you are turning the globe around for convenience. The direction in which the Earth's rotation axis points doesn't really swap between summer and winter - which hemisphere is leaning towards the Sun changes because of the Earth's annual journey around the Sun.

more...

For PowerPoint slides and more see:
spark.iop.org/seasons-thermochromic-globe

Demonstration B: Skydome

This demonstration uses a lamp and a transparent dome attached to a globe to show how the path of the Sun across the sky is different in winter and summer.

Equipment

- World globe (eg 40 cm diameter)
- A small transparent dome (eg half of a 4 cm clear plastic bauble)
- Lamp
- Blu-Tack or sticky tape
- Books to adjust height of lamp (optional)

Procedure

1. Use Blu-Tack or sticky tape to attach the dome to the globe so that it covers the UK.

2. Place the globe about 1 m from the lamp (the Sun). Adjust the lamp's height so that it is the same as the globe's equator.

3. Position the globe so that the northern hemisphere is tilted away from the Sun.

4. Spin the globe anticlockwise about its axis so that the reflection of the lamp appears on the base of the eastern edge of the dome, travels up the dome and sets on the western edge.

5. Repeat, but this time tilt the globe's northern hemisphere towards the Sun (the arm of the globe may get in the way when you spin. Detach and re-attach dome as required).

A transparent dome attached to a globe to demonstrate seasons

Teachers' notes

Students should see that when the northern hemisphere is tilted away from the Sun (first day of winter in the UK) sunrise to sunset takes less than half a spin, day is shorter than night and the Sun follows a low path across the sky. When the northern hemisphere is tilted towards the Sun (first day of summer in UK), the Sun follows a high path across the sky, days are longer than night and it is warmer because the sun's radiation warms the ground for more time.

more...

For PowerPoint slides and more see:
spark.iop.org/seasons-skydome

Activity 1: Spreading sunlight

In this activity students use a torch and tilting board to explore how the intensity of sunlight depends on the angle at which it hits the ground.

Equipment

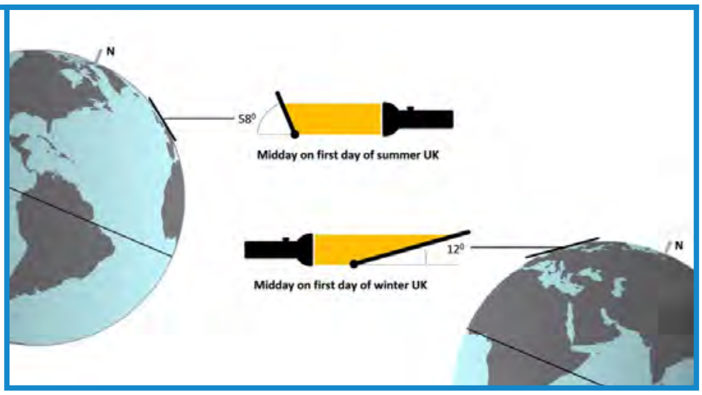
Each group of students will need:

- Mini-whiteboard or board with paper attached
- Torch or lamp
- Cardboard cylinder
- Two different coloured marker pens
- Protractor (optional)

Procedure

Ask the students to:

1. Put a cardboard cylinder around the end of the lamp/torch.
2. Place the board so that it is perpendicular to the light source.
3. Use a marker pen to draw around the area where the light falls.
4. Place the board at an angle and use a different coloured marker to draw around the new area where the light falls.



Sunlight angles for summer and winter in the UK

Teachers' notes

To model midday on the first day of summer they should tilt their board to 58°. For the first day of winter in the UK its 12°. It is warmer in summer because the sun's radiation is spread out over a smaller area and so the ground warms up more quickly.

more...

For PowerPoint slides and more see:
spark.iop.org/seasons-spreading-sunlight

Activity 2: Seasons on exoplanets

In this activity students use a ball and stick to model the motion of a planet around a star and deduce how its seasons may be different to those on Earth.

Equipment

Each pair of students will need:

- Lamp
- Polystyrene ball
- Bamboo barbecue skewer (length of 30 cm approx.)
- Marker pen
- A copy of the activity sheet (see page 12)

Procedure

Students should follow the instructions on their activity sheet to model a planet with a highly elliptical orbit and a tidally locked planet which always has the same face towards its star.

Exoplanets poster

Our brand new exoplanets poster (included with this issue of *Classroom Physics*) is a great introduction to exoplanets for students.


The ball and stick model of an exoplanet orbiting its star

Teachers' notes

A planet with a highly elliptical orbit will have seasonal variations, but they would not be like those on Earth. The whole planet will experience the same season at the same time: summer when it is closest to its star and winter when it is furthest away. In the course of a year, its orbit may take it in and out of the 'habitable zone' where conditions for life are thought to be most favourable. Life might evolve to hibernate for part of the year, or to aestivate when the temperature is too high.
For a tidally locked planet there are no seasonal variations. Its day is as long as its year. One side of the planet will always be in daylight and hot, the other in permanent darkness and cold. There will be a twilight zone between these two regions which might be a suitable place for life. Alternatively, life might exist beneath the surface.

more...

For PowerPoint slides and more see:
spark.iop.org/seasons-exoplanets

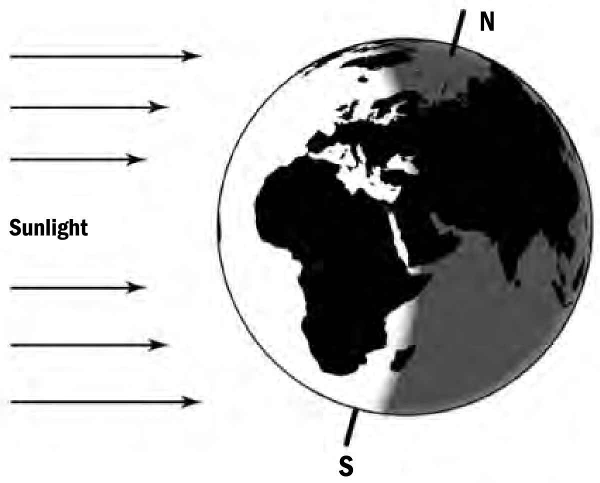
Activity sheet:
Seasons on exoplanets

In this activity you will find out about the seasons on two types of exoplanet: they can be very different from those we are familiar with on Earth.

Here on Earth, we experience seasons. This is because the axis of the Earth is tilted. In the summer, our part of the Earth is tilted towards the Sun and the weather is warm. In the winter, we are tilted away from the Sun and the weather is cold.

An exoplanet is a planet orbiting a star other than our Sun Astronomers have discovered several thousand exoplanets orbiting stars in our galaxy, the Milky Way.

If we lived on an exoplanet, what would its seasons be like?



The Earth when it is winter and daytime in the UK.

What you'll need:

- Lamp
- Polystyrene ball
- Marker pen
- Bamboo skewers

What you need to do:

The lamp represents a star. The polystyrene ball represents an exoplanet. A skewer through its centre represents the axis on which it spins.

1. On your 'exoplanet', mark the N and S poles where the skewer passes through the ball. Draw a line round the ball to represent the exoplanet's equator.

2. You should know why we experience night and day. Make your exoplanet spin on its axis and discuss with your partner why this gives night and day.

3. You should know why we experience seasons. Tilt the axis of your exoplanet and move it slowly round the star. Make sure that the axis is always tilted in the same direction (for example, towards the window). Discuss when the planet will experience summer in the northern hemisphere and when it will experience winter.

4. Astronomers have discovered that some exoplanets orbit their star so that the same side always faces the star. Move your exoplanet round its star in this way. Discuss whether this planet will experience day and night. Will it experience seasons?

5. Astronomers have discovered that some exoplanets have orbits that are not circular. They orbit their stars in elongated ellipses. For part of the year, they are close to their star but then their orbit takes them much farther away. Move your exoplanet in an orbit like this. Discuss what the seasons will be like on such an exoplanet. How will its seasons be different from what we experience here on Earth?

Seasons stories

Seasons in the Sun

The number of darker areas on the surface of the Sun, sunspots, varies in an approximately 11-year cycle. Within that cycle, solar activity passes through three 'seasons' leading to variation in the 'space weather' (electromagnetic conditions in the solar system) experienced on Earth. During solar maximum, the Sun is highly active and unpredictable. In the declining phase, the activity becomes both more moderate and more regular. Finally, in the solar minimum activity is limited.

Strange seasoning

Whilst the pattern of having four equal seasons is normal for those of us used to the Earth, the orbital dynamics of other planets create conditions that can seem, literally, alien. Mars experiences seasonal variation in atmospheric pressure. The pressure is 25% lower in winter than summer because of gas exchange between the atmosphere and its dry-ice ice caps and the planet's orbital eccentricity. Uranus' high orbital tilt (82°) results in seasons 20 years long. Due to its lack of axial tilt, Mercury doesn't experience seasons at all.

The Sphinx and the equinoxes

Several ancient sites have been constructed to mark astronomical events – but not all the claims of such representations bear scrutiny. Some researchers have claimed that the monuments in the area around Giza were constructed to form a representation of the sky. The Sphinx, they suggest, stands for the constellation of Leo, the Nile for the Milky Way and the three pyramids, Orion's belt. Furthermore, the archaeologists Graham Hancock and Robert Bauval have claimed that the sphinx is positioned so that it faces the rising Sun during the vernal equinox. However, when the sphinx was constructed, the equinox Sun was in the constellation of Taurus, debunking this theory.

Early space weather

One of the first observations of space weather was made in 1724 by clockmaker George Graham. He noted rapid deflections of a compass from north, as much as half a degree in a few hours. Periods of intense solar activity can disrupt satellite-to-ground communication and long-range radar signals, damage spacecraft electronics and increase high altitude radiation which can harm astronauts.

Seasonal lag

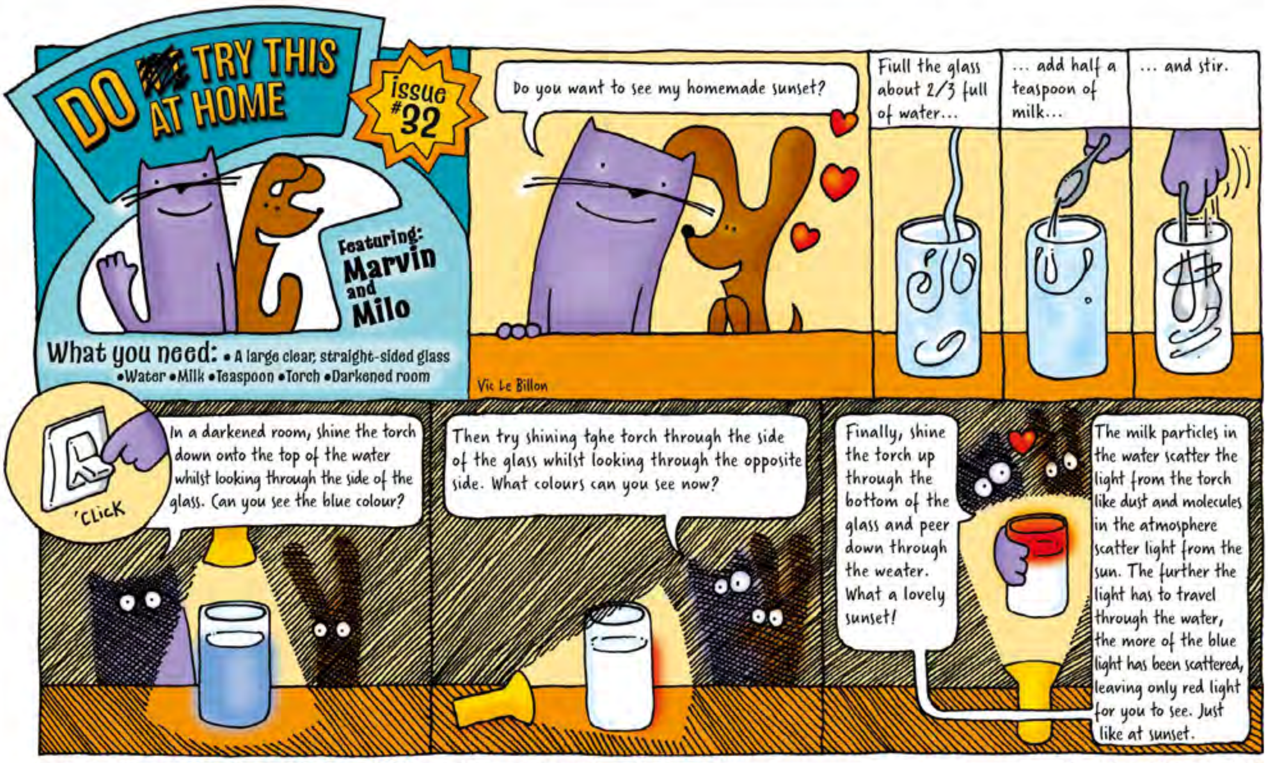
It might seem intuitive that the maximum air temperature during a year will be experienced around the summer solstice, when solar radiation is maximum. However, the peak temperature normally arises sometime after the solstice, a phenomenon referred to as 'seasonal lag' and occurs due to water in the atmosphere. Water has a relatively high latent heat of condensation and freezing (the energy absorbed or radiated during state changes) so that, rather than increasing the air temperature, some solar radiation causes changes in the state of atmospheric water.

The length of seasonal lag can range from as little as 15-20 days at the poles to as much as 2.5 months. For example, in San Francisco average temperatures can peak as late as September due to the moist atmospheric conditions.

spark.iop.org/stories-physics

These stories were collected by Richard Brock, lecturer at King's College London and former physics teacher.

Follow him on Twitter **@RBrockPhysics**



Download more Marvin and Milo activities at iop.org/marvinandmilo

Physics*education*

Physics Education is our international online journal for everyone involved with the teaching of physics in schools and colleges.

Editor-in-chief Gary Williams highlights his favourite papers on **the seasons** from the archive and the current volume. These papers should provide support for developing a topic for your scheme of work that could include environmental issues, mathematical modelling and hands-on experiments.

Access over 50 years of articles at **iopscience.org/physed**

Affiliated schools have free access – email **affiliation@iop.org** for a reminder of your log in details.

Credit: Physics Education

The parallel globe: a powerful instrument to perform investigations of Earth's illumination

The parallel globe is a teaching device where an ordinary globe has what are effectively little sundials placed all over its surface: short sticks radiating perpendicular to the surface. This allows students to carry out a number of observations during the course of a day or a year and discuss the implications of their findings. On the *Physics Education* webpage for the paper there is a video, freely available to anyone to see, which explains how the parallel globe can be used. This is another example of an astronomy activity that can be done during the day.

bit.ly/PEDglobe

Textbook images: how good is the seeing?

You may have seen the film *A Private Universe* (**learner.org/series/a-private-universe**) where students struggle to explain the seasons despite having studied at graduate level. At one point, we see a solar system drawing. Those of us who know what it shows interpret the elongation of the circular orbits as perspective. Other folk see ellipses. What we see and how we interpret it is very individual. What's more, Berit Bungum's 2013 paper *Textbook images: how do they invite students into physics?* showed that images get copied from book to book down the decades, so getting them right is important.

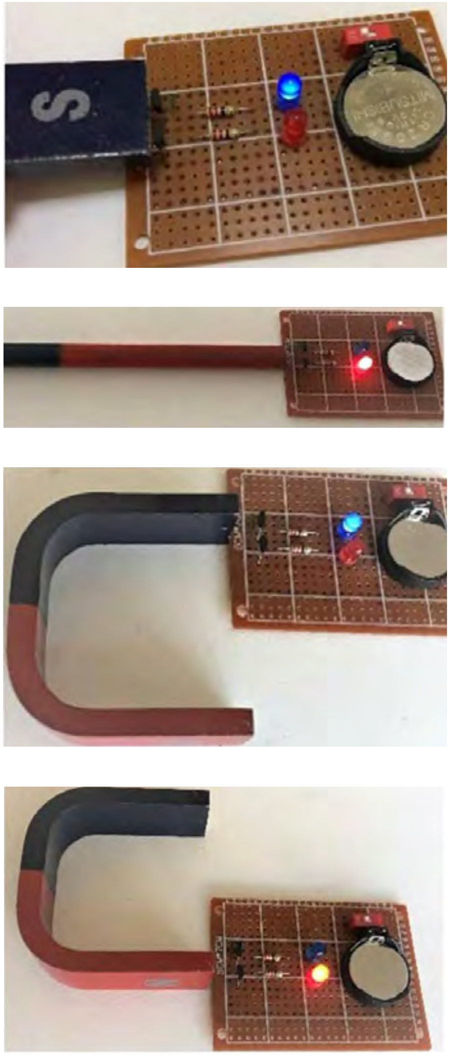
The 2014 paper *Astronomy textbook images: do they really help students?* examines a number of images including those showing the seasons. It makes several important points but this quote: "Too often it is assumed that the meaning of images may be inferred simply by looking at them" is worth keeping in mind. What to you and the illustrator is obviously a flat plane showing the Earth at different points in its orbit, might be seen as something very different by a student. Ask them to describe what they think diagrams show to check that you're all on the same page.

bit.ly/PEDimages &
bit.ly/PEDtextbookimages

Quantitative experiments to explain the change of seasons

It can be tricky to find astronomy experiments to carry out because we often lack telescopes or are teaching at the wrong time. This paper uses photovoltaic panels to perform a series of experiments that explain how the seasons occur and can link to climate change issues. A number of activities are described ending up with those involving specific heat capacity, so are probably more suited to 16-18 year old students, but the ideas are simple and not difficult to bring down to the level of younger age groups. Evidence is provided that shows the teaching module had a measurable effect on students, but it's worth pointing out that the sample size was small.

bit.ly/PEDquantseasons



Credit: Physics Education

Indication of the poles of various magnets with marked poles

A magnetic polarity detector

I always enjoy seeing an idea for a series of experiments unfolding as you come up with new ideas or new bits of apparatus. When students can investigate phenomena and build their knowledge step by step you hope they are gaining experimental skills as well as understanding. This paper gave me just that feeling of enjoyment as I imagined students performing some fairly modest experiments with magnets, but then being able to move on to electromagnets of different shapes. Often the pressures on time mean that just as students get to grips with one experimental method or bit of equipment, we move on to the next. Yet some of my best practical lessons with students came when we did the same thing again and again, building confidence in their ability. This polarity detector is inexpensive and will allow teachers to build a sequence of experiments, and students to build confidence in their experimental skills.

bit.ly/PEDpolardetect

Quick Links

An electrostatics paradox - This will make your students think
bit.ly/PEDelectrostatics

Infinity: some close encounters in physics teaching - This will also make your students think
bit.ly/PEDinfinity

What happens next? Ink markers - This will make you and your students think!
bit.ly/PEDinkstarter

Demonstrating buoyancy in waterlogged ground - Big things in the ground may float!
bit.ly/PEDbuoyancy

Simple fluorescence imaging to identify the purity of olive oil: an activity in an optics course
bit.ly/PEDoliveoil

Enhance your smartphone with a Bluetooth Arduino nano board
bit.ly/PEDnanoboard

Inducting a slinky

The paper *Students' report on an open inquiry* looks at the physics of toys and sports, getting students to think up their own home experiments that they could complete and present findings for during online teaching and learning. This approach seems to have produced ideas that were novel as well as some that are fairly standard, in that most students will be able to reproduce them. One of the examples given is finding the inductance of a slinky. Straight away you will no doubt think about how the inductance will depend on how spaced apart the coils of the slinky are. What shape graph might that produce if the axes are inductance and length? What metal is a slinky made from? Papers like these, where you start asking questions about items you are very familiar with but which never crossed your mind, are always worth a read.

bit.ly/PEDinductslinky

Modelling climate change

Climate change is a hot topic at the moment, and only looks to be getting hotter. Predicting the future of the atmosphere is going to rely on modelling. The paper *How much is not enough? One-, two- and three-atmospheric-layer models for Earth's energy balance* is a good example of modelling the atmosphere and the differences the initial assumptions to the model can make. The paper would be suitable for teachers of students aged 16 years old or above. With this age group, you could tie in a number of other interesting topics with the model, such as how the Sun radiates, satellites and data collection, atmospheric composition over time and so on.

bit.ly/PEDbalancemodels

talkphysics

David Cotton, editor of our online discussion forum, chooses his favourite TalkPhysics discussion threads on **the seasons.**

Log in or register to join the conversation at **talkphysics.org**

Teaching the seasons

The seasons are something that all UK and Ireland students experience. There are some good ways to illustrate how the tilt of the Earth can change the area over which the light from the Sun is spread out. A recent discussion around the seasons has featured some ideas on the IOPSpark website.

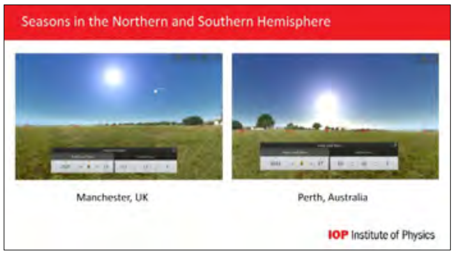
bit.ly/TPseasons

More thermochromic paper

Thermochromic paper can be used in lots of ways to teach the seasons. It can be done with a flat sheet and changing the angle of a heater to the paper. You can even be a bit more creative and add strips of the thermochromic paper to a globe. This thread has the method and a nice description of how thermochromic paper works.

bit.ly/TPthermo2

Seasons in the northern and southern hemispheres



Another way to show what is happening with the seasons is to use a program like Stellarium. Resources from the Yorkshire and North East England regional day include a guide to using the software in the classroom by Daisy Fox.

bit.ly/TPhemiseasons

Seasons diagnosis

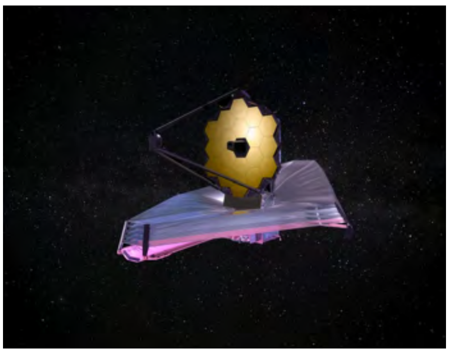
Stuart Farmer has created a repository of diagnostic questions across all topics, including the seasons. Feel free to use them - and add your own to the thread.

bit.ly/TPseasonsDQ

physicsworld

Stories from our magazine for the global physics community. Visit **physicsworld.com**

Credit: 24K-Production/NASA/Shutterstock



James Webb Space Telescope in space

A new cosmic dawn

As NASA's James Webb Space Telescope (JWST) gears up to open its eyes on the universe, Keith Cooper explores the mission's troubled past, its technological advances and the exciting future ahead for astronomy. The original deep-field image taken by the Hubble Space Telescope is one of the most iconic images in astronomy. Inspired by this timeless image, astronomers began planning a new mission to study the early universe – one that would see even further back in time, to 300 million years after the Big Bang when some of the first galaxies existed. But to do so required the biggest observatory ever to be conceived, one much larger than Hubble's 2.4 m mirror. The answer: the JWST (originally the Next Generation Space Telescope) – a huge spacecraft with a 6.5 m segmented primary mirror that promised a whole raft of new discoveries. First pegged for launch in 2007 at a cost of $1bn, the JWST is now estimated to cost $9.7bn.

bit.ly/PWjameswebb

How physics can help COVID-proof everyday

The emergence of a new variant of the coronavirus has put a constellation of researchers – virologists, immunologists and epidemiologists chief among them – in the hot seat as political leaders and public health experts seek answers to questions about how transmissible it is and whether it erodes pre-existing immunity. But while attention for the moment is on the life sciences, physicists also have a role to play in stopping the virus that causes COVID-19. Indeed, in the longer term, insights from physics could drastically reduce transmission of other respiratory pathogens, too. Take social distancing. Signs asking people to keep 2 m (or 6 feet) away from others have become ubiquitous during the pandemic. But according to Varghese Mathai, a physicist at the University of Massachusetts Amherst in the US, these precautions are ineffective. In fact, they could even do more harm than good.

bit.ly/PWcovidproof

IOPSpark

This is the first of our IOPSpark perspective pieces written by teachers about physics education research and teaching.

Read more at **spark.iop.org/perspectives**

What is physics?

IOP coach and teacher Carole Kenrick writes:

"At the start of the school year when I first meet my GCSE students, I ask them to write a letter introducing themselves. I provide some prompt questions, and show how I would answer them about myself to give them an idea of what I'm after. This year I shared that I am Belgian and that I speak French, I have a fluffy ginger cat called Benjie, I play quite a few musical instruments (and will be writing physics revision songs), I love roller skating (and that roller skating is full of physics) and I care a great deal about nature and sustainability. I explain the purpose of this exercise: for me to understand their goals, motivations, challenges and interests so that I can teach them as effectively as I can.

"Some students write a couple of sentences that give me little to go on. I now know that they have a pet dog and they like football. Others will offer me pages of passionate prose, full of perceptive insights and radical honesty. I've had a number of students come out to me on the page.

"There's one question I always ask. Do you have any questions about physics? The answers I get here are some of the most revealing.

"Among my Y11 students this year the most common questions were: what is physics, why do we have to study physics in school (the 'have to' makes my heart sink), what jobs can studying physics help with, who invented physics and who was the first physicist?

"My students have spent eleven years of their life in school, and the last two studying physics as a separate subject. And yet at no point have they explicitly been taught what physics is, why they should study it and how it might help them in the future.

"This is not unusual. And so I spend a lesson answering their questions."

more...

To find out how Carole addresses this, read the full article at **spark.iop.org/collections/what-physics**

CLEAPSS is an advisory service supporting science and technology in schools. Its advice and guidance is recognised by Ofsted and the HSE for safe practice for practical work in schools. Visit **cleapss.org.uk**

Credit: CLEAPSS

New air rifle guidance

Over the last few months CLEAPSS has been working on updating their guidance on the use of air rifles in science lessons.

It is a misconception that air rifles are banned in schools. It may come as a surprise that they can actually be used for dynamics experiments.

This new guidance is split across five documents which you can find by searching on **science.cleapss.org.uk:**

- GL370 is a guide which acts as a general overview on their use – including various legal points. For example, there exists a maximum energy of air rifle which can be bought without the need for a firearms certificate (note that the limit varies depending on which country you are in).

- GL371 describes the process of mounting the air rifle on a wooden board to make experimental work safe, secure and reliable.

- Documents PP118, PP119 and PP120 include practical procedures on various experiments which can be undertaken. These experiments allow for the determination of the speed of an air-rifle pellet by means of timer gates (PP118), indirectly through momentum transfer (PP119), and inventively through the use of a ballistic pendulum (PP120). CLEAPSS have also produced videos to accompany each of the practical activities.

Practical work with air rifles can bring a new dimension to lessons on dynamics. It allows students to complete calculations with very fast-moving projectiles using real world data, and will undoubtedly keep them engaged.

more...

Search for these documents at **science.cleapss.org.uk**

Inventive Podcast and classroom resources

The Inventive Podcast, hosted by Professor Trevor Cox, will give physics students an insight into engineering careers and the challenges that physics and engineering are looking to solve.

Each episode tells the stories of engineering through interviews with engineers from a diverse range of backgrounds and educational routes, some of whom who went into their job through a traditional undergraduate route, but others did not:

- Ruth Amos won an engineering award at the age of 15 for her design of a mobility device and set up her own company instead of going to university.
- Jack Hawarth became an engineer through an apprenticeship route and talks about how much he learnt from those who trained him.

It features many fields from femtech (technologies focused on women's health) to risk engineering and space exploration. Each episode also weaves in a piece of fiction writing including semi-biographical stories, tales of possible futures, poetry and rap.

NUSTEM at Northumbria University have created classroom materials linked to the podcasts. IOP Affiliated Schools will each receive a careers poster with one of the featured engineers - further posters can be requested from the website below. There are also KS3 science question sheets linking curriculum topics to the work of the engineers plus English worksheets looking at issues raised by the podcasts. The materials will help subject teachers include careers in the curriculum and support those in England to meet Gatsby Benchmark 4.

Listen to the Inventive Podcast - and order more careers posters - by visiting:

hub.salford.ac.uk/inventivepodcast

Inventive is funded by the EPSRC and led by the University of Salford.

Book now for the F4S Careers Jam 2022

Get your students involved with Founders4Schools' free virtual Careers Jam on Tuesday 3 May, where they will hear from industry leaders and young professionals in a variety of panel discussions and workshops designed to guide them in their career pathways. Students will also be able to engage directly with organisations and educational institutions about the opportunities available to them through a range of virtual booths where they can chat live with prospective employers and educators and arrange one-to-one meetings.

You can encourage your students to attend individually, or teachers and career leaders can register on behalf of their students to attend as a group.

Register at **f4scareersjam.com** or email **careersjam@f4s.org.uk**

Founders4Schools (F4S) was established in 2015 by serial entrepreneur, Sherry Coutu CBE, as a solution to the rising skills gap she saw in the workforce. She wanted to make it easy for educators to improve the employment chances of young people by bringing inspirational role models into the classroom. It has a digital platform that offers a free, simple and quick way for educators to book role model encounters either in the classroom or virtually.

Visit **founders4schools.org.uk**

IOP Affiliation Scheme: print copies of Classroom Physics – and more

Join the 1,300 schools and colleges already affiliated to the Institute of Physics to receive:

Classroom Physics magazine four times a year

Physics World monthly magazine, keeping you in touch with developments and providing inspiration for your students

Online access to Physics Education, our international journal for everyone involved with the teaching of physics

Resources such as posters and careers materials produced by IOP and other organisations.

Open to schools and colleges in the UK and Ireland and to British international schools.

iop.org/affiliation

Visit **thebigbang.org.uk/the-big-bang-competition/get-inspired** for project ideas, resources, tips and guides.

Enter your science or engineering project online by Sunday 20 March 2022 at **thebigbang.org.uk/competition**

Inclusion in Schools

This whole-school initiative aims to support secondary schools in England to address barriers that can affect student educational pathways.

Participating schools are provided with exclusive access to expert-led webinars, networking opportunities with other schools, resources and more. This project can help you to identify and address the barriers which can lead to underrepresentation in all subjects, including physics.

The ASE are delivering this project on behalf of the Institute of Physics, building on its previous work around improving gender balance in physics. Fully funded by the Department for Education.

For more information,

email **inclusioninSchools@ase.org.uk**

or visit **ase.org.uk/inclusion-in-schools-project-support-equity-diversity-and-inclusion-your-school**

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

INCLUSION IN SCHOOLS

Science and Technology Facilities Council

The Science and Technology Facilities Council have created new resources celebrating Women in STEM.

Read the stories of some of the many great women in the fields of Science, Technology, Engineering and Mathematics from around the globe, from the first computer to medical breakthroughs. And read about today's women working at STFC's ISIS Neutron and Muon Source, from a Mechanical Technician to the Group Leader of the Molecular Spectroscopy Group.

bit.ly/STFCwomen

The Great Science Share for Schools 2022

We want 5 – 14-year-olds to ask, investigate and share the scientific questions that really matter to them. Focusing on the importance of sustainability, GSSfS 2022 has a Climate Action theme, encouraging pupils to ask questions exploring how their actions might make a difference to the world around them. They can then gather evidence to help answer those questions and then share their questions and findings with others.

It is free to take part, but you must register via the website to access the resources and receive the newsletter.

Find out more at **greatscienceshare.org** and follow **@GreatSciShare**

Great Science Share for Schools

The 2022 IOP Ireland Tyndall Lecture

Credit: Jon Chase

Think you know physics? Think again. Join rapper and science communicator Jon Chase as he brings the physics of the classroom to life in this year's Tyndall Lecture

Date: Wednesday 23 March 2022, 2:30 – 3:30pm

Venue: Online

Audience: Teachers of students aged 14-16 in Ireland are invited to book on behalf of their class.

Further details and registration:
ireland@iop.org

You can also catch up on the 2021 Tyndall Lecture, *Tuning in tothe Radio Universe from Ireland* given by Professor Peter Gallagher, head of astrophysics at the Dublin Institute for Advanced Studies at:
bit.ly/tyndall21

IOP Scotland Stirling Physics Teachers Meeting

Date: Thursday 26 May 2022

Venue: Stirling Court Hotel

Further details and registration:
stirlingmeeting.org/home

This event is also part of the four-day residential IOP Scotland/SSERC Physics Teachers' Summer School which takes place between Wednesday 25 to Saturday 28 May 2022. The summer school will include a wide range of workshops, talks and seminar activities delivered by SSERC staff and IOP Scotland Physics Coaches together with a visit to the University of St Andrews and the IOP Scotland Stirling Physics Teachers' Meeting. For further details and registration see **sserc.org.uk/professional-learning/secondary-clpl/physics-clpl/**

Note: The IOP is monitoring the evolution of risks associated with COVID-19 both domestically and internationally. As this is an in-person event, COVID-19 mitigation arrangements will be in place.

For CPD support, contact us at **education@iop.org**

For support running CPD, contact our Professional Practice Group **Education-ppg@iop.org**

Keep up to date with CPD events for teachers at **talkphysics.org/events**

IOP DOMAINS online CPD

Our award-winning online teacher CPD programme is available any time with videos recorded by our CPD specialists on:

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- Electricity
- Light, Sound and Waves
- Matter and Nuclear Physics
- Space

Visit **iop.org/domains**