June 2020 | Issue 53

Classroom physics

The magazine for IOP affiliated schools

Home learning resources for schools and colleges

The socially just physics classroom

Stories from Physics in difficult circumstances

iop.org

IOP Institute of Physics

This issue

News

Features

Resources

Digests

Opportunities

Teaching in lockdown

A message to teachers from Charles Tracy, IOP Head of Education

Credit: Charles Tracy

The last few months have probably been the most challenging of your teaching career. As well as shifting, almost overnight, to new ways of teaching and learning, you are faced with huge uncertainties about exam results, long-term planning and when and whether face-to-face teaching will resume for all your students.

There are, of course, some specific challenges with teaching physics remotely: the lack of access to laboratory practicals and the difficulty in engaging in meaningful dialogues. As ever, teachers have risen to the challenges. The IOP applauds your determination and we have been amazed at your ingenuity – and we are doing what we can to help you.

We have collected some links to recommended resources on **IOPSpark**. You can see these on the following page.

We are also continuing to run CPD sessions, albeit in a new format. These online sessions are listed on our **TalkPhysics events page**. Rather like other forms of web-based interaction, we are learning quickly about what works well. There are genuine advantages: they do not require travel and can take place at different times of the day. Therefore, they can be shorter, more focused and more ad hoc.

We are hopeful that we can take both the learning and everyone's new-found facility with the tools into our work beyond the crisis, thereby extending and improving our offer to teachers.

Another positive change within this crisis is the increased media interest in the sciences and scientists. The quality of discussion on current affairs programmes has risen enormously by the inclusion of the likes of David Spiegelhalter and Hannah Fry. It has been a change to hear more from spokespeople with a clear scientific basis for their analysis and they have been refreshing in their honesty, clarity and willingness to give straight answers to difficult questions.

It is also the case that **physics is playing its part**. The astonishing speed with which the structure of COVID-19 became known was a huge achievement. And many manufacturers have retooled to provide respirators and PPE during the crisis.

We might hope that there is an increase in both the faith that the public puts in its scientists and in the consideration young people give to the sciences when they make their choices about the future.

As ever, but particularly with all the current challenges, those futures are shaped and made possible by your devotion to them, to their education and to physics. We thank you and wish you continued strength, power and leverage to your elbows.

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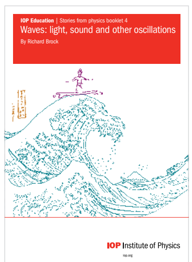
With this issue...

Stories from Physics
Waves: light, sound and other oscillations

The fourth booklet in our series features, amongst others, the innovative use of a cat for a radio receiver and mysterious signals from space that researchers found were being emitted from their own kitchen.



Home learning resources for schools and colleges during COVID-19

The rapid actions required by schools following government decisions to go into lockdown in the UK and Ireland presented unique challenges to everyone involved in teaching physics. There was precious little time to plan for moving to remote learning.

Our team of expert physics teacher coaches began work immediately to plan support for the study of physics at home. They have recommended resources, practical activities and CPD opportunities all chosen to help you support students during these exceptional circumstances when most students, teachers and technicians are at home.

We have categorised the materials by physics topic, suggested age range and type of resource. We are adding more resources and online teacher workshops every week.

Additionally, students aged 15-16 who would in normal circumstances been taking public examinations may find **MyPhysicsCourse** a useful place to explore to help them decide on which subjects to study next year.

Resources by physics topic

You can also browse by resource type within these collections

- 1. Earth and Space
- 2. Electricity and Magnetism
- 3. Energy and Thermal Physics
- 4. Forces and Motion
- 5. Light, Sound and Waves
- 6. Properties of Matter
- 7. Quantum and Nuclear Physics

Resources by age range

- 11 – 14 year olds
- 14 – 16 year olds
- 16 – 19 year olds

Resources by type

- 1. Videos to watch at home
- 2. Home experiments
- 3. Questions to check understanding and identify misconceptions

Support for sharing resources

- **TalkPhysics** - our online education discussion forum
- **@IOPTeaching** on Twitter has new ideas every day
- Direct support - **contact your local IOP coach**

Live online events

- **CPD workshops** for teachers and technicians
- **Webinars for the physics community** - a series of talks given by physicists for the physics community. You don't need to be an IOP member or even a physicist!

Follow the IOP Education Department on Twitter @IOPTeaching

What support will you need in the short, medium and long term?

Since the social distancing measures were introduced, we have been talking to teachers across the UK and Ireland about how we can support you and your schools to carry on teaching remotely.

We have heard first-hand from our school-based coaches, run a survey and invited teachers to focus groups (online of course). We have spoken to new teachers and very experienced teachers, those whose primary focus is physics and those with another specialism, and from all sectors of education.

Claire Aspinall, IOP Education Development Manager said: “We are building a picture of what we need to do as a community to ensure that secondary school students can study and enjoy physics despite the disruption which looks set to continue into the autumn term and possibly beyond. We will then build these needs into plans we are creating to support the new IOP strategy focusing on the transition to more online ways of teaching and learning, and trying to minimise the negative impacts on the development of early career physicists.” Teachers’ concerns broadly fell into five main areas, all underpinned by a concern for student and staff mental well-being:

1. **Suitable resources** – this is a completely new way of teaching, affecting all teachers whether new or highly experienced. Finding and evaluating resources to support home learning whilst also developing ways to replace the structure of the classroom are huge challenges.
2. **Practical activities** - getting hands-on is crucial for physics, both to help students’ understanding of core concepts and also to develop the skills needed by a physicist.
3. **Support for teachers** – a particular concern for trainee and early career teachers and those teaching outside their field, who need extra support teaching physics and may feel isolated.
4. **Exclusion** – there are wide concerns over digital exclusion and unequal access to broadband, hardware (and software) for teachers and students.
5. **Teaching and learning online** – managing expectations of parents, students and teachers themselves about what is possible during this period needs to be addressed, with teachers finding they don’t have the support they need to answer them.

IOP response short term: we have created and signposted to a large collection of high-quality resources to support home-learning across the curriculum at all secondary stages. We have moved our teacher CPD online and have been running virtual drop-in sessions to offer tailored support.

Medium and longer term: we will look for ways to help teachers who would like extra support and investigate how we can support teachers struggling with online teaching and learning. We want to be able to facilitate the sharing of resources, working practices and new pedagogy for the benefit of the community.

more...

Explore our remote learning resources at **spark.iop.org/covid-19-support-schools-and-colleges**

Find CPD events at **talkphysics.org/events**. If you would like to contribute to this work, contact **claire.aspinall@iop.org**

Do Try This at Home

IOP staff from across the organisation have got together to create a new series of physics videos to help parents and carers get their children excited about science at home.

Called Do Try This at Home, these short,easy-to-follow films are accompanied by step-by-step instructions, explanations and ideas for further exploration on our website.

Our team of science communicators are making these films in their homes around the UK and Ireland, using basic household materials and filming them on their phones. We’ll be releasing new films regularly to ensure there’s always something new to try, and we’re encouraging people to upload photographs or videos of their own attempts to social media using **#IOPathome**.

Credit: IOP

Our Do Try This at Home videos are designed for families to have fun with physics in their kitchens, bathrooms, gardens and living rooms

Aimed at parents and carers with primary and early secondary school aged children, we want to get as many children and young people – and their families – as excited about physics as we are, especially at this difficult time.

more...

To see the films, visit **iop.org/athome**

IOP Institute of Physics

Information for IOP members during COVID-19

Our **online hub** for members signposts advice and support throughout this period.

News from across the UK and Ireland

Wales

We are delighted to announce that the Welsh Government has agreed to continue funding our education projects to March 2021:

Stimulating Physics Network Wales provides a team of professional coaches who offer free high quality and bespoke CPD to teachers of physics and their students. We are currently seeking newly qualified or non-specialist teachers who would like support. We are also able to help with adapting to the new curriculum and providing remote support to students.

Improving Gender Balance had a successful pilot year and is recruiting three secondary schools and their feeder primaries in South Wales for the next school year. It's a fantastic opportunity to support teachers in developing measures to address gender stereotypes and their impact. We provide a Gender Balance Coach, who identifies areas for improvement and tailors bespoke support packages for each school.

more...

Join these projects or find out about support in Wales by contacting Samantha Borley at **education-wales@iop.org**

Scotland

During May, 2020 we had to cancel our flagship events, the Stirling Physics Teachers Meeting and Physics Teachers Summer School. Instead, in the first four weeks after Easter over 400 teacher hours of career-long professional learning (CLPL) were delivered online.

Our team of coaches organised on average two online sessions per week including a TeachMeet, allowing teachers to share ideas, workshops on using online tools to teach physics remotely, and more informal Virtual Physics Staffroom sessions to allow isolated teachers to get together to talk physics education over a coffee.

Working in partnership with SSERC, we organised a Virtual Summer School. You can catch up with resources and videos from the events in the TalkPhysics IOP **Scotland Online CLPL group**, including what would have been the opening keynote lecture at the Stirling Meeting, **A Remarkable Century of Physics**, to celebrate the centenary of the IOP.

more...

Join IOP Scotland's teaching email group **SPUTNIK** for news, information about CLPL and discussion **education-scotland@iop.org**

Ireland

Physics Student of the Year Award in Ireland and Northern Ireland - Would you like to reward and acknowledge the efforts of a special student in your class? Do you think an award could raise the profile of physics in your school? Nominate up to two students at Leaving Certificate or A-level. Find out more and apply **here**.

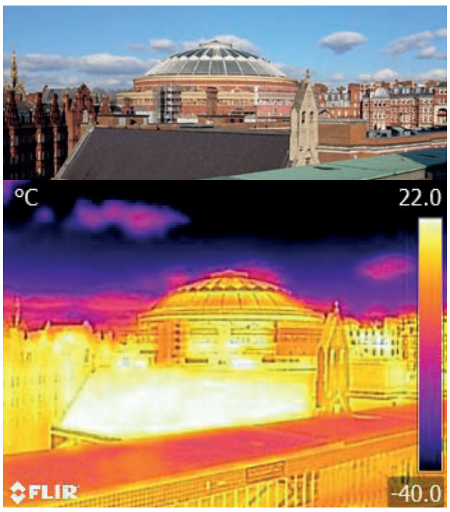
Teacher CPD – thank you to over 150 teachers who have attended our online CPD webinars since school closures began in March, we greatly appreciate your commitment to improving students' online learning experiences. Teachers explored online resources such as Isaac Physics and the Virtual Physics Lab software to help support remote physic teaching (those attending received free access to VPLab).

Frontiers of Physics 2020 - we made the difficult, but necessary, decision to cancel our flagship teacher event due to take place on 19 September. But it will be back, bigger and better, in September 2021!

more...

Get in touch with your local IOP coach via **education-ireland@iop.org**

Using infrared to explore the atmosphere



Credit: RMeTS

The images show the Royal Albert Hall in London in the visible and the infrared range. Why are different parts of the buildings different temperatures? Why is the sky warmer near the horizon? Find out by watching the films!

We need a climate-literate generation with core STEM skills to enable us to find the scientific and technological solutions to deal with climate change.

The Royal Meteorological Society has created a set of six **Physics in the Atmosphere** films showing how key physical processes in the atmosphere can be demonstrated using an infrared camera or even a simple infrared thermometer.

The infrared camera, or thermometer itself, uses the properties of black body radiation to establish the temperature of an object, which can in turn be linked to remote observations of the Earth and the differences in electromagnetic radiation from the Earth's surface and the top of the atmosphere. Each film is accompanied by some short questions to test understanding.

The films were made in conjunction with atmospheric physicists from Imperial College London, supported by the IOP's Environmental Physics group. We'll be working with the RMetS to produce teaching resources showing how the atmosphere, and climate change specifically, can be used as an approach to teach core physics and chemistry.

more...

RMetS has resources suitable for home study on its schools' website **MetLink**.

Credit: Martyn Win for Spacex/ University of Exeter

Investigating light and shadows as part of the 'Shadow Puppets' project

Re-energise your teaching with the Sci-Arts Creative Teaching Resource

Design and populate your own alien planet, choreograph your way into the intricacies of protons and electrons, explore a big scientific idea through a live art installation – these are just some of the activities available within the new online Sci-Arts Creative Teaching Resource which went live recently.

Developed by a team including experts from the University of Exeter, Science and Technology Facilities Council, University of Birmingham and the Institute of Physics, the resource supports creative science teaching practice. It not only helps teachers engage learners with science, but it also helps them to develop learners' creativity - and their own creativity in teaching science.

The resource has grown from the EU-funded project CREATIONS which developed arts-based creative approaches to science education across 11 countries. Project materials created by researchers, teachers and other educators across the EU have now been honed for use in UK classrooms for students aged from 7 – 18 years, supporting teaching and learning that is rich in both knowledge and creative opportunities.

The resource is based on eight features of creative science education which were identified by the CREATIONS team:

- Dialogue – between learners, teachers, scientists and artists
- Transdisciplinarity – bringing together ideas and processes from different disciplines
- Individual, collaborative and communal activities for change
- Balance and navigation – balancing structure and freedom
- Empowerment and agency – empowering students and giving them appropriate agency
- Risk, immersion and play – space to make mistakes, get engaged and have fun
- Possibilities – what if?
- Ethics and trusteeship – considering implications and impacts of science and related learning

By providing a series of tools that teachers can use to plan their own creative science-arts projects, the resource supports busy teachers to take a creative approach, raising questions such as:

- How can we find ways to use the different knowledge and processes of the sciences and the arts to solve common problems?
- In your teaching, how can you allow for problem-finding, exploring, reasoning, reflecting, questioning and experimenting?
- How can you mix learning key concepts and facts with knowing how to experiment, how to make art, and helping you and your students recognise feelings and emotions in all of this?

A set of 12 tried-and-tested teaching guides provides exemplars of the eight creative features in action and supports teachers in using creative pedagogies as part of their curriculum sequence. Each is a printable one-page overview, colour-coded to highlight the creative science teaching features. They also contain links to contextual information, or teaching materials that have been created by other teachers on the project.

The **Sci-Arts Creative Teaching Resource** is free for schools to access, thanks to funding from the University of Exeter ESRC Impact Acceleration Account. So, go ahead and download it now to start getting creative with your planning.

The teaching guides

These are all based on projects that have taken place in UK schools, often developed in conjunction with classroom teachers. Titles include:

The Artful Physics Competition: challenging learners to present key concepts in physics to their peers through an art form of their choice

Crater Investigation: using the story of meteorite and impact craters to engage learners in creating, designing and reporting their own scientific investigation

Life in Science: bringing theory to life by linking key discoveries to individual scientists and their social / historical context.

more...

sciartsedu.co.uk

The project team are interested to hear how you use it either on Twitter **#SciArtsEdu** or contact Dr Kerry Chappell via **k.a.chappell@exeter.ac.uk**.

EU-funded project CREATIONS (Grant Agreement No.66517; www.creations-project.eu)

The socially just physics classroom

Professor Louise Archer and Emma Watson from the Aspires 3 project write about the latest findings

In recent years, you may have heard the term **science capital** being used and you may even have a vague idea of what it means. But what can you do to support and build the science capital of your students?

Our team of researchers are investigating the science and career aspirations of 10 to 23 year-olds in the **ASPIRES longitudinal research study**. This work led to us coining the term 'science capital' and we are working through a range of projects to translate the findings of our research into day-to-day teaching practices that can support inclusive, socially-just science teaching to engage all students.

Science capital can be thought of as a conceptual holdall that encompasses all of a person's science-related knowledge, attitudes, interests, participation (outside of school), and their science-related social contacts and networks. Together, they produce an individual's sense of science being 'for me' - or not. Evidence shows that the more science capital a young person has, the more likely they are to aspire to, and continue with, science post-16 and the greater the likelihood that they will identify as a 'science person'.

Earlier this year, we published the report from the second phase of the ASPIRES study. In it we discuss our findings including how the factors shaping a young person's science identity, aspirations and progression are complex and multiple.

Creating a 'socially-just classroom' where all students feel they want to engage with science lessons can reduce some barriers. Our wider work, conducted in primary and secondary schools in partnership with teachers, has developed the Science Capital Teaching Approach.

After just one year of implementing the approach, we saw growth in student science capital, improved attitudes to science, and increased aspirations to study science at A level, when compared to control groups. Students and teachers also reported wider participation and engagement in classes. One teacher said, "I think there's more student engagement ... especially by students who don't normally contribute in lessons."

Our work is ongoing, but we already have a wide range of articles and resources to share. If you'd like to download the ASPIRES reports, teaching approach or find out more about our research, please get in touch with us!

more...

ASPIRES is funded by the Economic and Social Research Council. Follow the project on Twitter **@ASPIRESscience** or email **aspires@ucl.ac.uk** to find out more.

The infographic shows three key areas:

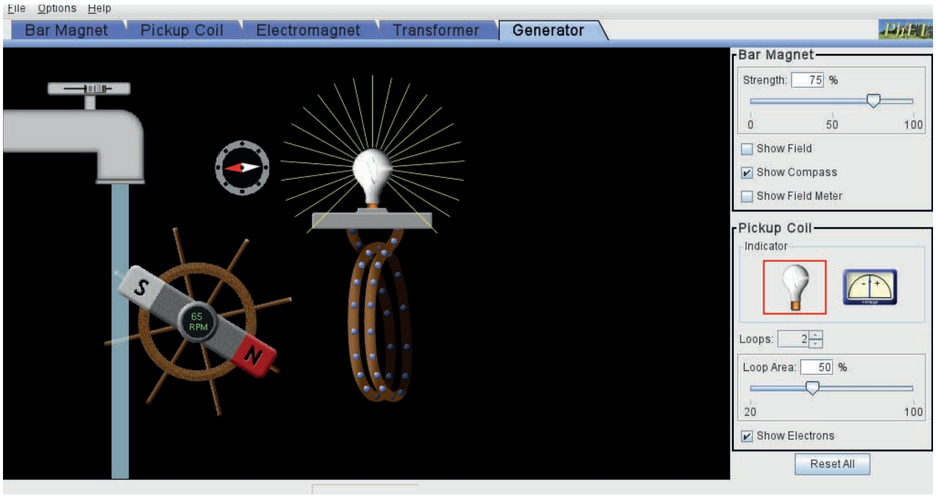
Capital-related inequalities include the impact that science capital has on the extent to which a young person experiences science as being 'for me', or not. Associations of science, but particularly physics, with 'cleverness' and masculinity have also been found to restrict and narrow the likelihood of a young person identifying and continuing with science post-16. These impact especially on girls and other students from communities that are traditionally under-represented in physics.

Educational factors and practices, such as schools, teachers, careers education and gatekeeping (e.g. restrictive entry to the most prestigious science routes) also have a big impact on young people's science identity and trajectories. Our research shows that these practices are particularly prevalent in physics.

Dominant educational and social representations of science - some barriers are much harder to reduce or remove than others. Eliminating the association of physics with "cleverness" and masculinity will require a societal overhaul, but teachers can start to change young people's preconceptions. Actively challenge stereotypical ideas such as, you need a "physics brain" or to be "naturally clever" to do well in physics, and that physics is more difficult than other subjects.

Credit: Archer, L., et al. (2020). ASPIRES 2: Young people's science and career aspirations, age 10-19. London: UCL Institute of Education.

Physics education research



Credit: PhET

Faraday's Electromagnetic Lab on PhET has been found to be as effective as a classroom activity for student learning outcomes.

Can students learn from simulations home alone?

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.**

If you would like to join other physics teachers interested in engaging with the latest research, discussing classroom applications, attending seminars and getting involved with research, email us at **research@teachphysics.co.uk.**

or join the Physics Education Research (PER) group on Talk Physics at **talkphysics.org/groups/physics-education-research-per**

The transition to online teaching as a result of the COVID-19 crisis has caused many challenges. Amongst the difficulties of online physics education is the loss of the opportunity for face-to-face practical work for students. One approach to this change is to replace laboratory-based practical activities with virtual simulations. One of the most widely used sets of freely available simulations can be found on the **PhET site** produced by the University of Colorado Boulder.

What is perhaps less well known is that there has been significant research into the value, benefit and best practices for using these PhET simulations. This **research** is available on the site itself and it is well worth reading.

A recent paper, entitled **Can students learn from PhET Sims at home, alone?** asks a question that many teachers may currently be thinking about, trying to decide how much time and effort they can and should put in when setting up tasks based around the simulations to be done at home.

The research team were interested in what happened when students worked at home without the usual direct teacher guidance and peer interaction and whether this changed how useful the simulations were. The researchers split a group of 77 students aged 15-18 years in half and compared working at home and in class groups using the same simulations. They assessed learning through targeted conceptual questions and student interviews. They found that both groups benefited from using the PhET simulations but that some simulations seemed to be more beneficial than others for both groups. The **Faraday's Electromagnetic Lab** led to particularly large learning gains.

When working at home, if given the right scaffolding, students were able to benefit to about the same extent as the in-class group, suggesting that the simulations can be a useful tool for home learning, without direct teacher intervention. The success, or otherwise, of using the simulations in both groups seemed to be dependent upon the level of scaffolding and support that was provided to the students.

Although a small-scale study, the answer to the question, "Can students learn from PhET Sims at home, alone?" seems to be "yes". And, perhaps surprisingly, you don't need to give students that much guidance.

In this study and similar ones, the use of what are referred to as driving questions, for example "Can you make a light bulb light with a magnet?" seems to help maximise the learning. Students do not seem to benefit from lengthy and detailed instruction sheets which can take a significant amount of teacher planning time – the students explored and learned more when given lighter guidance.

To maximise the learning benefits of the PhET simulations, the best thing you can do is to write a few good, driving questions and then let the students get on with it.

more...

Can students learn from PhET sims at home, alone? by Wendy K. Adams, Zachary Armstrong, and Cynthia Galovic (2015) is available from PER-Central

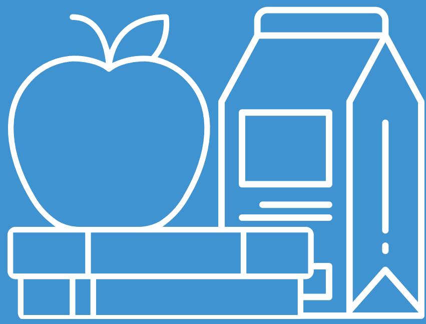
NB Some PhET sims only work in specific browsers but with a little investigation, there is detail on the site as to how to get them running.

Pull out and keep!

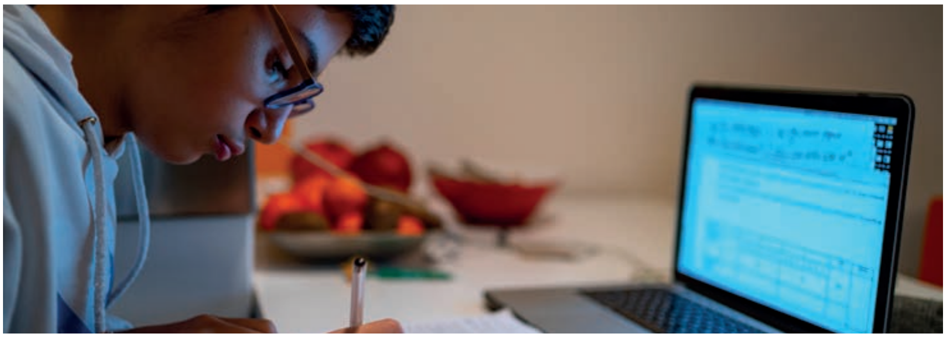
Physics at Home

What's inside:

spark.iop.org/athome



A physics teacher and IOP teaching coach (and parent) writes...



Credit: Shutterstock

From discussions on Twitter, there's a clear paradox for the profession at the moment: despite social distancing, teachers have never been so connected. In a range of different ways, responding to the needs of our students and depending on the resources available, science departments have worked together to offer improved home schooling at a time of crisis.

Colleagues have shared their approaches online, answering hurried questions about platforms and creating shared drives of teaching materials. The profession has shown the importance of skilled practitioners being able to adapt and innovate, in some cases producing complete sequences of lessons in a matter of weeks. And this has happened while working at home, or providing school places during the Easter holidays, as well as juggling the needs of their own families.

A consistent school approach has never been more important. Whatever advice you are given – including ours! – must be adapted to your setting. Speaking as a parent, it's much easier when my 11 year old gets work in a predictable way from all departments, even as the tasks themselves vary. My son is fortunate to have a laptop available, but you'll have already found that many students are working through phones or tablets. Some will have no reliable internet access or modern device.

The longer this continues, the harder it will be to set meaningful work which helps, rather than confuses students. We've all set cover work and returned to find it takes longer to correct misunderstandings than if we'd simply waited. Parents, however well-meaning, are the ultimate hapless cover supervisor – as I proved when trying to help with some geography last week.

What this means is that the attainment gap will inevitably widen during this time. All we can do as a profession is aim to be ready to support our students when we reach a new normal.

The Education team at the IOP is working to support students and teachers. Many of us are experienced teachers and wish we could do more, but we hope it has been helpful. We can't tell what the future holds, but we will continue to do what we can, one step removed from your virtual classrooms.

We're also doing what we can to support you as teachers with your own development. We have been able to transfer many of our workshops to online versions and make them available to anyone interested. In time, we'll be able to make it to your prep room for a workshop in person. But for now, we hope to see you online.

Ian Horsewell
IOP Professional Practice Group / Regional Education Manager (Midlands)

more...
Find IOP online CPD at
talkphysics.org/events

Activity 1: Whistling waveforms

In this activity, students download an oscilloscope app onto a laptop or phone to investigate pitch and loudness. You can use it to introduce waveforms of sounds.

more...
spark.iop.org/whistling-waveforms

Credit: IOP

This activity includes a video for students to watch featuring our IOP teaching coach Niloufar Wijetunge and her dog Jasper.

Equipment

Each group of students will need:

- A laptop (or a smartphone)
- Two different sized bottles with long necks (optional)
- A copy of the student activity sheet (download from **spark.iop.org/whistling-waveforms**)

Procedure

Students should follow the instructions on the student activity sheet (see next page).

Teaching notes

Soundcard Oscilloscope on a Windows laptop is ideal for students to use on their own as it provides a large display for easy comparisons of wave traces. If your students do not have access to a laptop, alternative free apps for smartphones or tablets are suggested on the activity sheet. If you recommend a different one, make sure it has a pause function.

If students can't whistle, they can ask another person at home to be their sound source. Alternatively, they could blow over bottles or use a musical instrument such as a guitar or a recorder. By following the instructions on their activity sheet they should see that when the sound is louder the peaks of the waveform are bigger, and that when the pitch is higher the peaks are closer together.

Learning outcome

Students can draw waveforms for sounds with different volumes and frequencies.

Do Try This at Home

From the **Institute of Physics**

Whistling waveforms

What you need:

- A laptop (or a smartphone)
- Two different sized bottles with long necks (optional)

Oscilloscope apps

If you have a Windows laptop,
download Soundcard Oscilloscope from
www.zeitnitz.eu/scope_en

Alternatively, use an oscilloscope app on a phone or tablet. Download a free one which allows you to stop the trace on the screen, such as:

- **Oscilloscope (xyz apps)** from the Play Store (tap screen to stop trace)
- **Oscilyzer** from the App Store (use pause button to stop trace)

Did you know

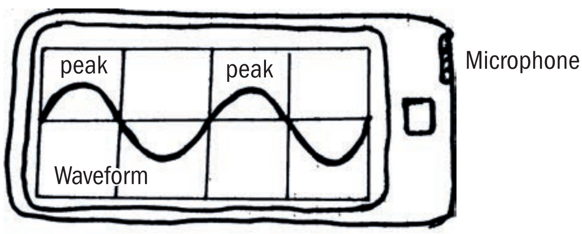
The highest pitch sounds humans can hear are those that make the air vibrate at 20,000 times a second. A dog can hear vibrations well above that at over 40,000 times a second.

What you need to do:

1. Watch the video at **www.bit.ly/DTTAHWaveforms**
2. Open the oscilloscope on your laptop (or phone).
3. Whistle and observe the trace on the screen. If you can't whistle, ask someone else to help or blow over a bottle to make a sound.
4. Whistle a loud, steady note and stop the trace. If you missed it, repeat to try to catch the waveform mid-whistle.
5. Repeat, but this time whistle more quietly. How does the waveform change with loudness?
6. Whistle with a high pitch and then a low pitch. How does the waveform change with pitch?

Now do this:

The waveform for a sound is shown below.



Copy the waveform and then sketch one for:

- a louder sound of the same pitch
- a quieter sound with a higher pitch

Something else to try:

In music, the waveform for a note that is an octave higher has twice the number of peaks. Blow over two bottles to make low and high pitch sounds. Compare waveforms and add water to tune your bottles so that they are an octave apart.

Activity 2: Elastic band universe

In this activity students build a model universe using washers or paper clips and elastic bands. You can use it to introduce Hubble's law.

Equipment

Each group of students will need:

- 6 assorted washers (or paper clips)
- 5 elastic bands of the same thickness (and ideally of different lengths)
- Small sticker to indicate 'home'
- Ruler or tape measure
- Graph paper (or laptop with Microsoft Excel or similar)
- Sticky tape
- A copy of the student activity sheet (downloaded from **spark.iop.org/elastic-band-universe**)

Procedure

Students should follow the instructions on their activity sheet to build a one-dimensional model of a universe. After expanding it to double its initial length they will need to stick the washers at the end of the chain to the table or floor to measure distances.

Teaching notes

When they plot a *change in distance* against *distance* graph, students should find that it is a straight line. Repeating with a different washer as the home galaxy reveals that the gradient of the graph is the same irrespective of which washer they consider to be 'home'. Like real galaxies, the galaxies in the model seem to move away from home, but home is not the centre of the expansion. Observers in all galaxies will see the galaxies move away from them with a speed that is proportional to their distance from their galaxy. This is known as Hubble's law.

Model	Universe
The washers do not expand	**Galaxies do not expand (they are gravitationally bound)**
The elastic bands expand, carrying washers with them	**Space between the galaxies expands, carrying galaxies with it**

Learning outcome

Students explain why observers in all galaxies see the galaxies move away from them with a speed that is proportional to their distance.

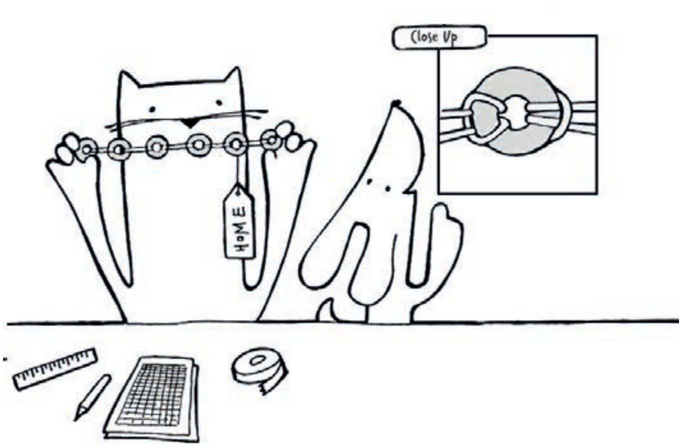
With thanks to the Perimeter Institute of Theoretical Physics for permission to adapt their activity

more...
spark.iop.org/elastic-band-universe

Do Try This at Home

From the **Institute of Physics**

Elastic band universe



What you need:

- 6 assorted washers (or paper clips)
- 5 elastic bands of the same thickness (and ideally of different lengths)
- Small stickers
- Ruler or tape measure
- Graph paper (or laptop with Microsoft Excel or similar)
- Sticky tape

What you need to do:

1. Make a model universe from rubber bands and washers, as shown above. Each washer represents a different galaxy.

2. Choose one washer to be the home galaxy, label it with a sticker. Label the other galaxies with letters A to E.

3. Copy the table below.

Galaxy	Distance from home/ cm		Change in distance/ cm
	Initial	Final	
A			
B			
C			
D			
E			

4. Measure the distance from the home galaxy to galaxy A. Repeat for the other galaxies and write the distance in the 'initial' column of the table

5. Expand the universe until it is twice its original length and then tape down the ends to a table or the floor to hold it in place.

6. Measure the new distance from the home to the other galaxies. Fill in the 'final' column of the table.

7. Subtract values in the second column from those in third column to calculate the change in distance.

8. Plot a graph of "change in distance" against "initial distance" and draw a line of best fit.

9. Repeat steps 2 to 9 but with a different galaxy as home galaxy. Compare the gradients of your two graphs. What effect does changing your home galaxy have?

Now do this:

The table below shows the speeds with which 5 galaxies are moving away from us, and their distances from us.

Galaxy	Distance/ 10^{20} km	Speed/ km/s
NGC 3627	3.1	750
NGC 4775	8.2	1900
NGC 3147	13.6	2500
NGC 6745	19.7	4250
NGC 554	22.1	5200

Plot a graph of distance against speed and write an explanation of why the graph supports the idea that the universe is expanding but it doesn't mean that we are at the centre of the expansion. Include diagrams if it helps.

Something else to try:

The elastic band universe is a one dimensional model. Make a two dimensional model using stickers on a balloon.

Physics*education*

Physics Education is our international online journal for everyone involved with the teaching of physics in schools and colleges. Affiliated schools have free access – email **affiliation@iop.org** for a reminder of your log in details.

Physics Education editor Gary Williams highlights his favourite papers on sound and waves from the archive (this page) and picks his top articles from the current volume (next page).

The Mpemba Effect

This effect can be investigated at home with a freezer or ice-box in a fridge and also offers opportunities for students to perform some online research. It is named after the young person who discovered it, Mpemba, and the story appears in the 1969 paper Cool? Mpemba found that, under the right conditions, hot water freezes faster than cold water.

Students could see if they can find evidence that this effect was known about prior to Mpemba's **"Cool?"** article in Physics Education. If they want to reproduce the effect, they will also need to prepare before starting the activity because it does not appear under all circumstances. Hence some further online research or some trial experiments need to be carried out. Success could be just reproducing the effect, before any experiment on relationships between variables is carried out. The explanation is still a matter for debate it seems, so plenty of research to do there too!

These papers are suitable for students to read themselves to learn more:

Cool?

The Mpemba effect, Shechtman's quasicrystals and student exploration activities

Cooler-lower down

Mind on ice

Cooler still - an answer?

Investigating the Mpemba effect: when hot water freezes faster than cold water

Water jets – with a pop bottle

Credit: Shutterstock

This erroneous diagram appeared in a GCSE textbook. Read more in **Demonstrating pressure at depths**.

With a simple plastic pop bottle and a pin, students can investigate water jets. The obvious activity is putting holes at different heights from the bottom of the bottle, filling it with water and seeing how far the jets go, then explaining why. Students might compare what they see to some of the diagrams of this activity shown in books and online. Lifting the bottle up so the jets don't hit the floor so quickly might help. Then students might investigate the head of water and how quickly the bottle empties. Having done that, they might put two bottles in series as described in the paper **Pin-hole water flow from cylindrical bottles.** Then they might investigate rates of emptying with two holes and even what happens if they throw the bottle up in the air.

These ideas and more are described in these papers:

Pin-hole water flow from cylindrical bottles

The whole truth about water jets

Demonstrating pressure at depths

Experimental determination of the contraction coefficient of a free jet of water

Freely rising bottle of water also demonstrates weightlessness

Filling or draining a water bottle with two holes

The Cartesian diver – with a pop bottle

Although an old favourite, don't forget how much you can do with a Cartesian Diver. My students would decorate the outside of their bottles with pictures of fish and sea weed and with a bit of coloured gravel in the bottom it looked just like the bottom of the briny. Rubber bands will sink in water, and a paper-clip fashioned into a hook on the end of the diver will allow the squeezer of the diver to hook the rubber bands and bring them to the surface. But we can add a little more to this by introducing a second liquid. Can the diver be made to stay at the interface between the two liquids? There are plenty of ideas in the below papers including a spinning diver.

These papers give you more ideas for physics with bottles:

Making a fun Cartesian diver: a simple project to engage kinaesthetic learners

Two-liquid Cartesian diver

Once more about the Cartesian diver

Vapor Cartesian diver

Physics*education*

During lockdown, articles from the vast Physics Education archive are being made freely available (no need to log in) to help provide some inspiration for teachers and students alike.

Visit **Physics Education at home: DIY activities for home learning**

Fierljeppen: pole vaulting for distance

It's not likely that students can try this at home but it's a novel and interesting example of some basic physics. Fierljeppen is a sport in the Netherlands and as the title says, it's all about getting up a pole and travelling horizontally as far as possible. The start is just like a pole vault, competitors run with a pole and vault, but then when the pole is moving towards the vertical and the vaulter has left the ground, the vaulter climbs up the pole as quickly as they can. This then allows them to cover the greatest horizontal distance as the pole falls down on the opposite side to that which they started from. Did I mention there's a ditch full of water?

The authors explain how they have created a model for this event, but it doesn't need to be complicated to be interesting. Think about climbing that pole. When you sprint with the pole you don't want to be going too fast. You want to be running just fast enough for the pole to get upright. The slower the pole is getting vertical the longer the time you have to climb it. Hence you might task students with calculating that speed, too slow and you don't get to the other side; too fast and you reduce your climbing time.

more...
Fierljeppen: pole vaulting for distance
Published 29 April 2020

Credit: Shutterstock

in this less well-known form of pole vaulting, the aim is to jump as far as possible with the help of a long pole. Athletes reach heights of 11.5 m and the record jumping distance is currently 22.21 m

Expanding physics learning beyond classroom boundaries

Under the circumstances this paper might help give you a few ideas on how you can reach your students if you can't see them face to face. The authors used WhatsApp to help teach their students:

"The unique contribution of this tool to physics education, is that it allows for open, immediate discussion of students' questions, which allows for their difficulties and misconceptions to be addressed. This use of WhatsApp made physics studies more accessible for students and more relevant."

Many of the points raised by the authors would be applicable to other platforms. There are some clear benefits to students but any reframing of the subject matter will give students the opportunity to approach the concepts being taught in different ways.

more...
Expanding physics learning beyond classroom boundaries — a case study
Published 20 December 2019

More recent articles
What happens next?

Credit: IOP

Investigating thermal conduction and latent heat:
what happens when ice cubes are placed on top of drinks cans in saucers of warm water?

Many of the What happens next activities will be useful for home-learners as students don't all need the apparatus to think about the questions:

Here are some suggestions:

- Does an orange float in rotating water?
- Bubbles have the power to lift grapes in lemonade
- Floating fruit: orange in water
- Forces at play: weights and a toilet roll
- Domino rally - who will win?
- Bouncing balls and a table - the question
- Bouncing balls and a table - the answer
- Ice cubes on drinks cans - the question
- Ice cubes on drinks cans - the answer
- Rolling cans - the question
- Rolling cans - the answer
- Mirror matters - the question
- Mirror matters - the answer

EIC is the Royal Society of Chemistry's magazine for teachers. Visit **edu.rsc.org/eic**

The 4 secrets of successful remote teaching

Tips for making distance learning effective

With the majority of educators remote teaching, everyone is concerned with how to make distance learning successful. For many, the first concern was grappling with unfamiliar technology. That is still relevant, but just as important are what you are teaching and how you are doing it, as the **Education Endowment Foundation** points out. It boils down to four not-so-secret secrets:

1. **Technology**

   There is no ignoring that without the internet and mobile phones, distance learning would be a lot harder. Even for those already pretty savvy, there is plenty to get to grips with. Thankfully, as ever teachers have been generously **sharing tips** and even providing **step-by-step guides**.

2. **Resources**

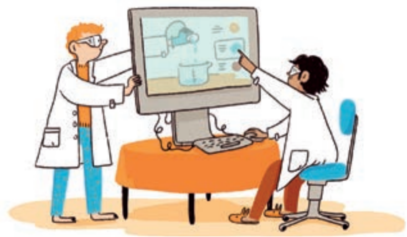
   Finding appropriate material, relevant to the curriculum and suitable for remote teaching, is vital. Which is where societies like the IOP and RSC come in. There is no better first stop for physics than **IOPSpark**, and for chemistry **RSC Education**.

3. **Approaches**

   You have mastered the technology and chosen your resources, now think about the how. Luckily, plenty of teachers and education researchers have considered it already. From **adapting flipped learning** to providing **timely feedback** through **quizzing**, there is help at hand.

4. **Being realistic**

   Successful remote teaching and learning require a hefty dollop of realism. Chasing the same results as you would in your classroom is a recipe for disappointment. Accepting the realities of the situation will help you and your students rise to the challenge.



Credit: Claudia Flandoli

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**

Advice for storing radioactive sources during the COVID-19 shutdown

Ensure that the radioactive sources are stored securely as per our guidance (**L93** pages 17-20). Ensure that the cabinet is locked and the store room it is in is locked.

If you have a Protactinium generator, keep the bottle upright in a larger plastic container with a tight-fitting lid. This should also be labelled. Store the Protactinium generator bottle in its secondary container in the steel store cabinet. If there is a leak, the secondary container will help prevent hydrochloric acid fumes damaging other sources.

Put leak-testing and store checks on hold, similarly the annual inspection and complete as soon as practicable upon return to the school. Do a quick visual inspection to ensure that all the sources are present as soon as possible.

Look at our **GL345 Guidance for science departments returning to school after an extended period of closure**.

Radioactive sources to avoid

Please do not buy any radioactive source offered by a supplier without checking **PS078 Choosing new radioactive sources for school use: advice for science departments** – some schools have been stung by spending a lot on a radioactive source and then subsequently being told by a RPO/RPA that they should dispose of it, which in itself can be costly.

If in doubt when purchasing radioactive sources, **contact CLEAPSS** first.

CLEAPSS podcasts

These give a 'fly-on-the-wall' insight into the kind of work we do, starting off in the areas of physics and technology. Find them on **cleapss.podbean.com**

talkphysics

Edited highlights from our online discussion forum. Log in or register to join these discussions at **talkphysics.org**

Credit: Shutterstock

A man is standing on a weighing machine on a ship …

Find your local physics network

Our discussion forum now hosts lots of local groups where teachers are sharing teaching ideas, resources from workshops and local knowledge. **Register or log on** and explore!

Supporting schools and colleges during COVID-19

This is a **discussion thread** dedicated to the issues of teaching during the pandemic. Scroll through to find videos, teaching ideas and discussions.

Weighing at sea – help!

A teacher posted, "I'm stuck on a question that none of my students have managed. A man is standing on a weighing machine on a ship which is bobbing up and down with simple harmonic motion of period T. Assuming the motion is vertical, calculate the amplitude of the ship's motion in terms of T if the scale reading of the machine varies between limits of m_1 and m_2, with $m_2 > m_1$." Can you help?

more...
Read the **full article**

physicsworld

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

How physics is helping the fight against the pandemic

While health workers and governments do their part, scientists are trying to understand the virus and develop vaccines and treatments. Jon Cartwright looks at how physics plays an important role in the fight. In particular, physics-based techniques play a huge role in the field of structural biology. The vast majority of biological macromolecule structures are obtained by X-ray crystallography, going back to 1934, when John Desmond Bernal and Dorothy Hodgkin recorded the first X-ray diffraction pattern of a crystallized protein, the digestive enzyme pepsin. Their work stemmed from that of physicists such as Wilhelm Röntgen, who discovered X-rays.

more...
Read the **full article**

Returning to the lab will be hugely beneficial for me

Daisy Shearer is a PhD student in experimental physics at the University of Surrey, where she studies semiconductor spintronics. She describes her experiences as an autistic person during the pandemic: "Big changes and unpredictable circumstances can be incredibly difficult for autistic people like me, and although there is a wide diversity of autistic experiences – we all have our own challenges and strengths – I think most of us have felt the impact of the pandemic to a heightened degree."

more...
Read the **full article**

Credit: Physics World

Inspiring space: Daisy Shearer in her lab at the University of Surrey.

Physics in difficult circumstances

All of us have been affected to some extent by the measures introduced as a result of the COVID-19 pandemic. A number of other physicists also produced great work under difficult conditions:

The Curies' 'potato-cellar'

Both Pierre and Marie Curie struggled to find appropriate laboratory space during their careers and produced their research in unusual settings. Despite being chief of the laboratory at the Paris Municipal School of Industrial Physics and Chemistry, Pierre lacked space for his work and set up apparatus in his students' rooms or worked in a corridor. Marie began her doctoral research in a converted storeroom that was damp and cramped.

After discovering radium and polonium, the Curies sought to produce pure samples of the new elements. To achieve this, they acquired a tonne of pitchblende ore but a shortage of laboratory space led to them using an abandoned shed that had been used as a dissecting room. Visiting chemist Wilhelm Ostwald described it as "a cross between a stable and a potato-cellar". Marie later reported: "Its glass roof did not afford complete shelter against rain; the heat was suffocating in summer, and the bitter cold of winter was only a little lessened by the iron stove, except in its immediate vicinity... Yet it was in this miserable old shed that we passed the best and happiest years of our life."

Schwarzschild's walk in the land of ideas

Karl Schwarzschild began his career at the German Astrophysical Observatory near Berlin. When the First World War broke out, though he was over 40, patriotism inspired him to join the army where he served in the artillery. Despite freezing conditions and when the fighting allowed it, he would catch up on his scientific correspondence.

In December 1915, a month after its publication, he received a copy of Einstein's paper on general relativity. It had been generally assumed that the nonlinear field equations in the paper would be challenging to solve. Remarkably under any conditions, but particularly so given the conditions on the front, within a month of publication, Einstein received a letter from Schwarzschild setting out a simple solution to the field equations. Einstein forwarded the letter to the Berlin Academy and it was published in January 1916. Schwarzschild wrote in a letter to Einstein: "The war treated me kind enough, in spite of the heavy gunfire, to allow me to get away from it all and take this walk in the land of your ideas."

Year of Wonders 1665-1667

Credit: Shutterstock

Many people have noted that Isaac Newton enjoyed a productive period between the summer of 1665 and the spring of 1667 after travelling to rural Lincolnshire to self-isolate – read about it on the **Woolsthorpe Manor website**.

Gentil's goose chase

A strong candidate for the title of most unfortunate astronomer is the extravagantly named Frenchman, Guillaume Joseph Hyacinthe Jean-Baptiste Le Gentil de la Galaisière. He believed that Halley's calculations for the transit of Venus were inaccurate and was sent by the French government to observe the 1761 transit in Pondicherry in India, then under French control.

Three months into his voyage, whilst breaking his journey at Mauritius, Le Gentil learned that the Indian Ocean was under the control of the British Navy. Undeterred, he continued his journey, only to discover, whilst off the Indian coast, that Pondicherry had fallen to the British. The transit occurred whilst he was returning to Mauritius and heavy seas and poor visibility interfered with his measurements.

Le Gentil stayed in Mauritius and made plans to travel to Manila for the next transit in 1769. However, arriving in Manila, after months at sea, he learned the governor would not allow him to establish an observatory. He again set sail for Pondicherry, now under French control, and set up his observatory. But the day of the transit proved to be overcast.

Devastated, Le Gentil left for home but his ship was nearly sunk by a storm and he was forced to return to Mauritius where he boarded a returning Spanish warship. He completed his journey over land from Spain to France, returning 11 years after setting out. On arrival, he discovered that he had been declared dead, his estate divided up, and his chair at the Academy taken by another scientist.

The story has a happy ending: Le Gentil published the story of his adventures, the book became a financial success and the scientist married a wealthy heiress.

more...

These stories were collected by Richard Brock, lecturer at King's College London and former physics teacher. Follow him on Twitter **@RBrockPhysics**

The ASE coronavirus hub

As a professional community dedicated to supporting excellence in science teaching and learning, we are determined to do whatever we can to support people over the coming weeks and months. On this page, you will find both a collection of materials created specifically by us that we hope may be of assistance during the current health crisis and a directory of links (with both **Primary** and **11-19** versions) to assets and resources created by others that we feel support our goal of promoting excellence in science education. The resources in both of these directories are being reviewed by the educators in our Primary and 11-19 committees on an ongoing basis.

Visit **ase.org.uk/ase-coronavirus-hub**

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

Keep your class connected with STEM and each other!

I'm an Engineer, Stay at home puts school students in direct contact with real engineers.

Everyone can take part from home, so it's especially useful while schools are closed during the Coronavirus pandemic.

Students can:

- Chat with real engineers, in real time
- Ask any questions they like
- Vote for their favourite engineer of the week
- It all happens online. It's safe and secure. It's free for most schools.

I'm an Engineer Stay at home | Tomorrow's Engineers

Key Stage 3 and Key Stage 4 free STEM resources

Home learning teaching resources and activities for 11-16 years old (Key Stage 3 and 4) including lesson plans, handouts and videos. Engage your child and keep them busy and learning while their school is closed.

Virtual Faraday Challenge
Due to the current circumstances we have adapted this year's Faraday Challenge developed in partnership with Airbus to bring you our first Virtual Faraday Challenge!

Young people can do this at home, in school, individually or as a group or family. It challenges young people to see if they can assist the work of Airbus in helping people around the world in times of need and work like engineers do in designing a new product.

The Institution of Engineering and Technology

Credit: Shutterstock

Break a flake: the NPL's first measurement challenge was "How strong are your breakfast cereal flakes?"

Measurement at home challenges

The National Physical Laboratory is setting students weekly challenges for young people to have some fun and learn about the science of measurement.

The NPL says: "How heavy, how long, how fast, how bright...?
All these measurements will be investigated and you will find out why measurement matters in our everyday lives. This is your chance to be curious, take some measurements and compare your results. Join in, have fun and learn a bit of physics!"

More
Visit the **NPL challenges webpage** and follow on social media using the hashtag **#MeasurementAtHome.**

NPL National Physical Laboratory

Find an online IOP CPD event

Credit: Shutterstock

Drop in Session – Earth in Space
24 June | 3:00pm - 3:45pm
Yorkshire and North East
Register

Engaging Students to Take Physics Further
24 June | 4:00pm - 5:00pm
Southern England
Register

Transition Between GCSE and A-Level Physics
25 June | 4:00pm – 5:00pm
London, East Anglia and Kent
Register

IOP Physics Forum Wales
25 June, 2& 9 July | 7:00pm – 8:00pm
Register

Electromagnetism
29 June | 12:30pm - 1:30pm
National
Register

6 July | 4:00pm - 4:45pm
London, East Anglia and Kent
Register

9 July | 4:00pm - 4:45pm
North West England
Register

CLPL: Teaching Physics Using Google Classroom – Virtual Experiments and Branching Forms
30 June | 2:30pm – 3:15pm
Scotland
Register

A Day for Everyone Teaching Physics
2 July | 9:00am - 3:30pm
Durham
Register

Biomedical Physics and SHM
2 July | 11:00am - 12:00pm
North West England
Register

Top Tips for a CERN School Trip
8 July | 4:00pm - 5:00pm
London, East Anglia and Kent
Register

Ivybridge Physics Day
30 June - 2 July | 9:00am - 5:00pm
Register

IOP Wales Cymru - North Wales Physics Teachers' Conference
13 - 16 July
Register

Light and Sound Pick 'n' Mix
13 July
Register

Visit talkphysics.org/events to view all of our CPD events

All the events listed above are open to all teachers of physics wherever you are in the UK or Ireland. We have included the locations to give an indication of the regional teams involved.

Contact your IOP regional education manager to find out about teacher support in your area:

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England

Yorkshire and north east
Jenny Search
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North west
Graham Perrin
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London, East Anglia and Kent
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For support running CPD, contact our Professional Practice Group

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