Classroom physics

March 2020 | Issue 52

The magazine for IOP affiliated schools

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the slink-o-scope

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IOP Institute of Physics

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Meeting of minds over teacher CPD

Credit: IOP

Teachers making electromagnetic trains at an IOP CPD day in February

Something special happened at the IOP in January. Something we hope will impact the future of the teaching profession. Something we feel is the beginning of a big national change.

We invited a range of people to come together to discuss where subject-specific CPD should be going. And they came - teacher training providers, subject associations including history, geography and maths, representatives from the Chartered College of Teaching and staff from the Department for Education, plus host, Professor Sir John Holman, former headteacher, chemist and education adviser.

Distinguished education researcher Professor Rob Coe had sent a review of evidence about the value of subject-specific CPD in advance of the meeting and this formed the basis for the discussion. The consensus was that at least 50% of CPD (over the course of a teacher's career) should be subject-specific. However, the current landscape – and recent government policy – shows this is far from the experience of most teachers. And Prof Coe's summary of existing research suggests just 1% of the national budget for education is currently associated with CPD.

What was exciting about the meeting was the level of consensus. And the desire for a national movement to ensure that all teachers, whatever career stage, have subject-specific CPD embedded in their roles.

We agreed CPD policy should work on three levels:

- Individual: give teachers autonomy and a say in their CPD. Subject-specific CPD should take account of knowledge gaps needing filling and be rich enough to challenge experienced teachers.
- School: governors and school leaders should provide opportunities for both generic and subject-specific CPD to all teaching staff.
- National: the government should develop a strategy for providing programmes and creating demand from teachers and schools.

The next stage is for a working group to hone these ideas with a view to developing a sustainable CPD strategy. We will also be pursuing government funding for subject communities to develop and run coherent subject-specific CPD programmes.

It is early days. But it feels now we are all ready to bring about change.

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With this issue...

Good practical science poster

Great ideas from the Association for Science Education. Includes the 10 Gatsby Practical Benchmarks

Marvin and Milo cards

Fun practical activities to do with sound from our cat and dog scientists

Quick practicals to fit into your lessons

Which cylinder has the greatest mass? What will happen when the ice melts? Just some of the many questions students can explore in our quick practicals at **spark.iop.org/quick**

We've launched a set of new classroom practicals on IOPSpark. They are easy to set up, usually require minimal kit and will take less than 20 minutes to run with most classes.

They are a response to the Gatsby Charitable Foundation's report, *Good Practical Science*, which outlined a framework for good practical science in schools. Its recommendations included:

- Be clear about the purpose of any practical activity.
- Plan activities so they are integrated with other learning.
- Students should experience a practical activity in at least half of their science lessons.
- Activities can be short or long, but should be varied in type.

"We know that there is a lot of material to get through when you are teaching and so fitting a practical into fifty per cent of your lessons can be challenging," Taj Bhutta, IOP school engagement manager said. "But we also know that practical science improves understanding of theory, develops important skills and engages students by showing them what scientific experimentation is all about.

"This is what motivated our quick practical project. With seed funding from Gatsby we've started collecting together a set of quick demos and class practicals that take 20 minutes or less to perform, but are still rich in physics. Many require minimal kit and prep, and so even if you are operating on a shoestring with little technician support you can still use them."

Each demo includes questions you could ask to promote class discussion and has a clear purpose in the form of a suggested learning outcome.

Covering all the domains of physics and spanning the 11 to 19 age group, we have also created supporting videos and visuals for display on the board.

more...
Explore the activities at
spark.iop.org/quick

Sound-themed examples from the collection feature in the physics pull-out on pages 9-12.

What does good practical science look like?

Credit: Gatsby Charitable Foundation

This was the question that Professor Sir John Holman, President of the Association for Science Education, sought to answer in his report *Good Practical Science*.

John and his team spoke to experts, reviewed literature and visited six countries including Finland, Singapore and Germany, where practical science education is known to be successful. Time and again we saw that practical science is key not only for learning but also for inspiring the next generation of scientists, engineers and technicians.

The report defines a framework of benchmarks for good practical science to guide science departments. Strikingly, many of the ingredients of good practical science are also the ingredients of all good science learning – expert teachers, well-planned lessons and technical support. So, much of what relates to good science teaching in general. John and his team also found that world-class practical science should be both frequent and varied in type, which is why they have supported the IOP to make it easier to bring well-planned and enriching practical activities into the classroom even if time is short.

Rob Cremona
Gatsby Charitable Foundation

more...
See the ASE practical science poster featuring the ten Benchmarks of Good Practical Science included with this edition of *Classroom Physics*.

Search Gatsby Good Practical Science to find out more about the good practical science benchmarks.

Credit: ASE

Llongyfarchiadau Cerian!

We were delighted to learn that IOP Wales teacher coach Cerian Angharad received an MBE in the 2020 Queen's New Year Honours List.

IOP head of education, Charles Tracy, said: "Cerian has dedicated her whole career to improving STEM teaching and learning. Her commitment has enhanced the lives, both in school and beyond, of thousands of young people. We are fortunate to have Cerian as part of our team, and we warmly congratulate her."

Hailing from Cardiff, Cerian began her career as a classroom teacher in Pontypool in 1994. Four years later, she became head of physics in a Welsh-medium school.

She joined the IOP as a physics teacher network coordinator in 2004, working to support other teachers and she has been a strong advocate for our Improving Gender Balance project. In this year she also began working for the Association of Science Education. In 2010 she co-founded education consultancy, See Science, which managed the Welsh STEM Ambassador Programme. She has always worked to ensure students study and enjoy science in Welsh, getting numerous resources translated. All this placed her at the epicentre of science education support in Wales.

Cerian described her reaction: "I couldn't believe it at first. I had to re-read the letter several times for the news to sink in. It's a huge honour to be recognised.

"I really believe that all young learners can succeed in STEM. Teaching science doesn't have to be just about getting grades, it can be about so much more."

more...
Read about Cerian at **beta.iop.org/mbe-iop-teaching-learning-coach-wales**

To find out about IOP support for teachers in Wales, contact **samantha.borley@iop.org**

IOP teacher support in Ireland

IOP education in Ireland is changing. We have welcomed our new Ireland national manager, Karen Sheeran and Engagement Officer, Lucy Kinghan, who work with our IOP coaches, to support teachers of physics and promote physics.

We now provide in-school support for teachers of physics. IOP coach David Keenahan said: "IOP coaches visit schools and work with teachers at any stage from junior cycle through to senior. These visits are particularly beneficial for newly qualified teachers or for teachers whose specialism is outside of physics. They can help with optimising use of existing laboratory equipment or deliver workshops on topics like electricity and junior cycle investigations."

Our Irish Improving Gender Balance project has completed its pilot year and is now working with almost 30 secondary schools to identify and address issues around gender imbalance in subject choices.

Events in Ireland 2020 (visit **iopireland.org** for more info):

- The Annual Frontiers of Physics Teachers Conference is scheduled for Saturday 19 September in Maynooth.
- The Northern Ireland Physics Teacher Conference takes place in June.
- Look out for evening workshops, including the ever-popular VPLab [Virtual Physics Laboratory] software, as well as Rocket Launching and Isaac Physics resources and more.

more...
Get in touch with your local IOP coach via **lucy.kinghan@iop.org**

IOP Schools and Colleges Affiliation Scheme

- *Classroom Physics* magazine four times a year with e-shots
- *Physics World* monthly magazine
- Online access to *Physics Education*
- Resources such as posters and careers materials

If your school is not yet affiliated, contact us at **affiliation@iop.org**, call **+44 (0) 20 7470 4832** or visit **iop.org/affiliation**

Follow us @IOPTeaching

Diagnostic questions in Scotland and England

British educationalist Dylan Wiliam famously said: "What is learnt is not related in any simple way to what is taught. Assessment is central to education."

Probing student understanding while learning is happening, as well as at the end of a topic, is vital. This requires a good bank of diagnostic questions so that you can shine light on students' ideas and misconceptions to address them early on.

We have been working with Professor Robin Millar, internationally renowned researcher in the field of science education, to run workshops to support teachers in developing their own diagnostic questions as well as gathering together questions to share more widely.

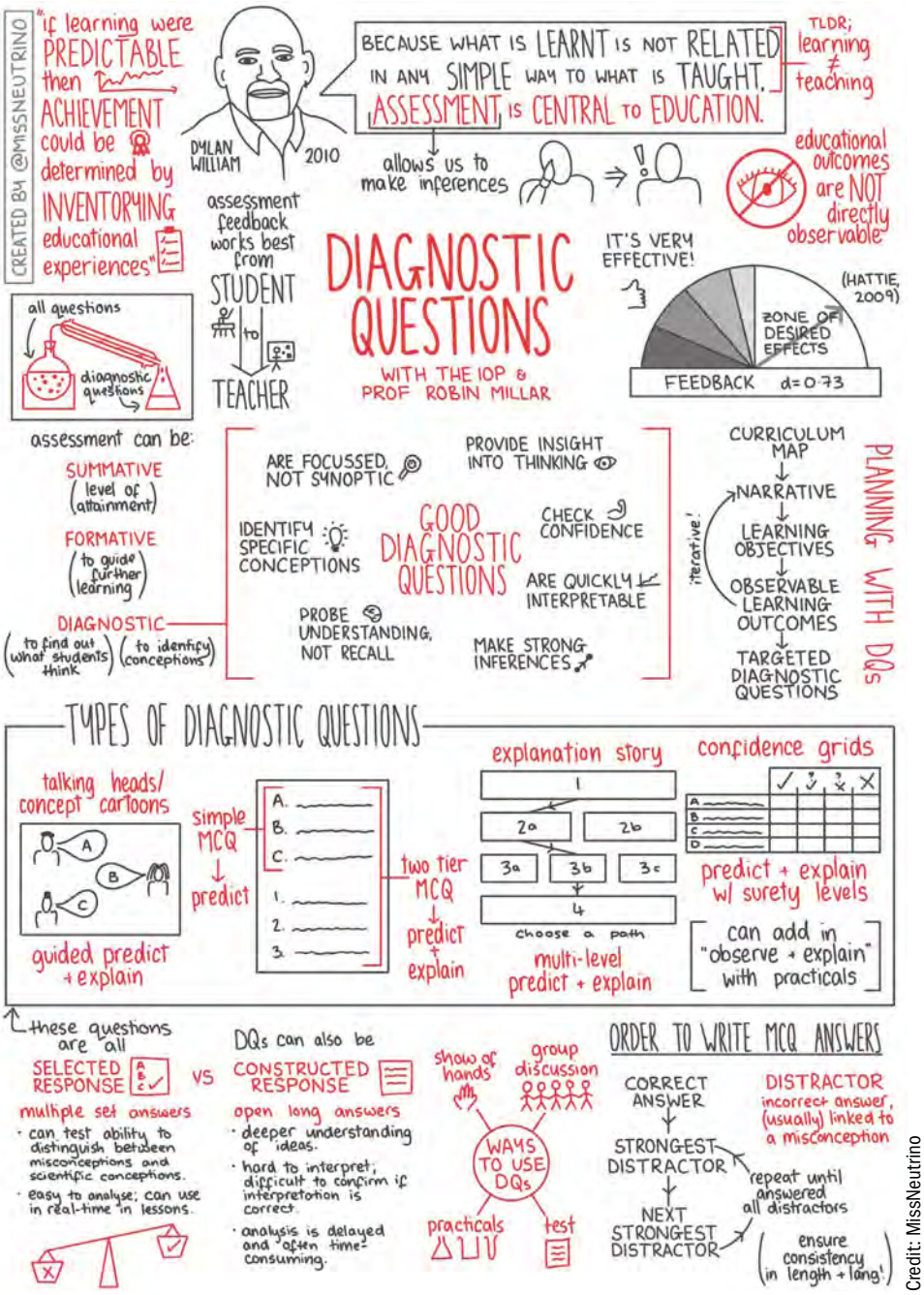
more...
Visit **spark.iop.org/misconceptions**

Scotland
There is a bank of questions collected by Stuart Farmer, IOP education manager for Scotland on TalkPhysics. He is organising a question-writing workshop at this year's SSERC physics teachers summer school in May.

more...
Browse questions at
bit.ly/IOPdiagscot
Contact Stuart at **stuart.farmer@iop.org**

England
We held our first question-writing workshop in November - get in touch to find out about joining future ones.

more...
IOP diagnostic tool is at
iop.org/diagnostic
Contact **Jessica.howell@iop.org** to find out about workshops.
Follow the discussion on TalkPhysics at
bit.ly/IOPdiageng



Physics teacher Alexia Wight (who tweets as @MissNeutrino) drew this infographic during our diagnostic question-writing workshop in November

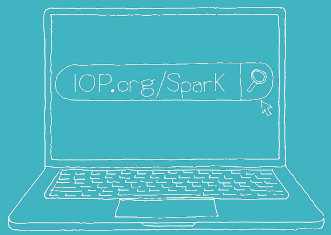
IOP teacher resources websites have moved!

Please note that all the resources from our teacher websites can now be accessed from IOPSpark. The original websites have now been switched off.

Teaching Advanced Physics (teaching ideas and resources – 16+)
spark.iop.org/teaching-advanced-physics

Supporting Physics Teaching (for those new to teaching physics or wishing to develop their existing skills – 5-16)
spark.iop.org/supporting-physics-teaching

Practical Physics (collection of experiments for 11-19)
spark.iop.org/practical-physics



Credit: IOP

Acoustics: sounds like a good career move

2020 is the International Year of Sound. Trevor Cox, professor of acoustic engineering at the University of Salford, writes here about possible career paths in sound. He is part of a team which has developed a set of teaching resources with curriculum-linked career information for students in the world of acoustics.

Professor Dame Anne Dowling, past President of the Royal Academy of Engineering, noted that acoustics is "paradoxically so ubiquitous that it [is] almost invisible as a profession".

But students who are into music and good at STEM might well want to study for a career in this area. Acoustic science and engineering might be less well-known than other STEM subjects, but as sound is everywhere, there is a wide range of fascinating careers.

The **salfordacoustics.co.uk** website contains careers-linked curriculum resources for schools and colleges. It has professionally produced resources on hearing and acoustics including:

- acoustics demos
- revision material for physics A-level
- high speed video and animations about sound
- ideas for lesson starters, careers resources and practical activities.

In particular, **salfordacoustics.co.uk/careers** has case studies where professional acoustical and audio engineers explain how their curriculum knowledge is used in their jobs.

Their roles range from Noise and Vibration (new materials to absorb sound and reduce environmental noise) to Digital Technology (machine learning to improve how sound is processed and the technology behind voice-activated controls), plus there are case studies from architecture and building acoustics, cars and hearing.

Starting salaries for a STEM acoustical engineer typically range from £21,000 to £25,000 and currently there are more jobs available than graduates with the right qualifications.

I'd advise students who are not yet sure whether they want to focus on sound to go for a general first degree like physics or mechanical engineering. Many people in the acoustics industry started liked this, specialising later by taking a post-graduate degree.

Routes into acoustics careers

A big decision for students interested in sound is whether they want to predominately follow a STEM or a practitioner route:

- STEM acoustic degrees produce engineers or scientists who design products, programme audio software or carry out scientific explorations. To follow this route, students need to study science and mathematics post-16. The two long-standing centres for these degrees are the universities of Salford and Southampton.
- Practitioner courses produce intelligent users of technologies who become skilled in the artistic use of sound. Jobs include sound engineers for live sound, recordist for TV or producers of podcasts. Many universities run practitioner courses in sound engineering and production, but beware, becoming a STEM engineer after a practitioner degree usually requires significant retraining.
- The Tonmeister course at Surrey University is a rare example of a degree that fully combines the STEM and practitioner routes.
- Another route opening up this year is a new level 4 apprenticeship for Acoustics Engineering Technicians. Another route opening up this year is a new level 4 apprenticeship for Acoustics Engineering Technicians, visit **instituteforapprenticeships.org** for more information.

more...

All resources can be accessed free of charge at **salfordacoustics.co.uk**

Find out about the Year of Sound at **sound2020.org**

Careers profiles

more...
salfordacoustics.co.uk/careers

Monitoring sound at Glastonbury Festival

"The local council's environmental health department sets us noise limits to reduce noise pollution. We work with the sound engineers to make sure each stage does not go over their limits." Elle Kalavsky

Hearing aid software engineer

"I love being able to have a real impact on people from helping to develop children's speech, to more sophisticated noise removal to aid people's day-to-day work and social life." Magnus Woodgate

Recommendations from Dave Cotton, IOP coach and physics teacher.

Credit: IOP

A student in Devon enjoys the confusaphone at a regional day last year

The confusaphone

"The confusaphone has always been one of my favourite lesson starters. It shows what happens when one's left and right hearing is mixed up.

"It is very easy to make the confusaphone following the instructions on the Salford Acoustics website and it's a great way to show how we can determine the direction of sound. It's a learning experience that is always enjoyed by the whole class."

salfordacoustics.co.uk/listening-devices

Visit the anechoic chamber

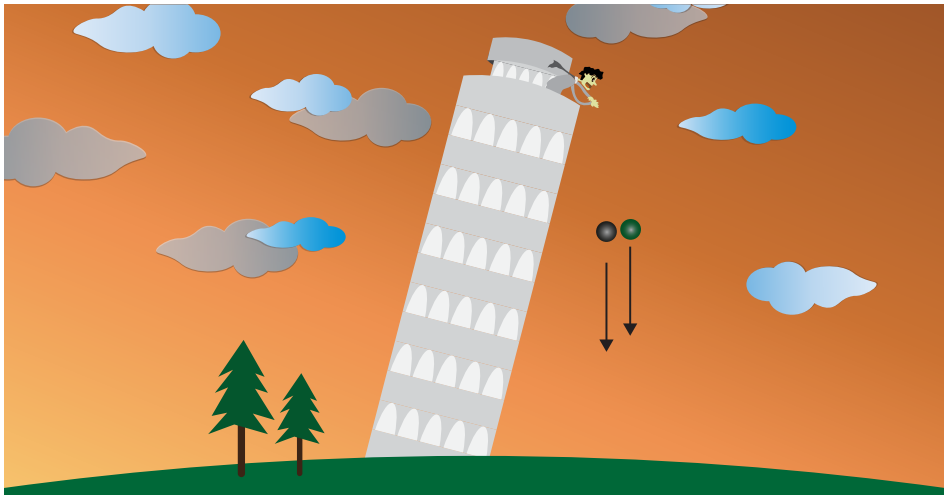
"For several years, I've been taking students to the University of Salford's acoustics department to see the facilities and learn about the courses on offer. They visit the anechoic chamber and reverberation rooms where they see the most vacuumed piece of carpet in the UK!

"The visits introduce students to careers in an area they had not heard of before. They hear about the work placements and realise they can have a meaningful and interesting career in an area of physics they enjoy - the acoustics of speakers, vacuum cleaners, washing machines and buildings all need to be researched. Every year, our students enrol on acoustical and audio engineering degrees."

Credit: Salford Acoustics

Salford and Southampton universities both welcome school visits. Contact the departments direct to arrange.

Physics education research



Chinn and Malhotra investigated children's perceptions when heavy and light rocks were dropped simultaneously

Credit: Shutterstock

What you know can change what you see

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.

Join the Physics Education Research group on Talk Physics at **talkphysics.org/groups/physics-education-research-per/**

or email **research@teachphysics.co.uk** to get involved with physics education research discussions.

Demonstrations are a powerful tool for teaching physics concepts. They allow teachers to guide students' attention to aspects of what they have observed that they might miss if they carried out the practical themselves.

Watching demos can also lower the cognitive load on students as they don't have to occupy their working memory with details of performing the task themselves. But research suggests teachers shouldn't assume that students will interpret what they see in the same way an experienced scientist would.

The knowledge people possess can have an impact on how they interpret events. This claim is of significance when considering how demonstrations (for example, the sound activities described in this issue) are organised in the classroom.

Educational psychologists Chinn and Malhotra showed 228 children aged 9-10 a demonstration in which a heavy and light rock were dropped simultaneously. The students were split into two groups. One group was informed that the rocks had different masses, the other was not. Before the drop, students were asked to predict what would happen. Then both groups were asked to report what they saw during the drop.

The authors had expected that most students who made an incorrect prediction (either the heavy or light rock will land first) would have been biased to observing what they had predicted. Indeed, only a quarter of students who believed that one or other of the rocks would hit first perceived a simultaneous landing.

However, the distribution of observations from the students who predicted incorrectly was similar to that of the group who had not been told the rocks had different masses. Most of the students who predicted that the light or heavy rock would hit first did not observe what they predicted. By contrast, students who predicted the rocks would hit at the same time were highly likely to report seeing a simultaneous landing.

The authors refer to this effect as schema-facilitated observation. They argue that when data is vague or ambiguous it can be hard to detect an appropriate pattern, and having a conceptual structure, or schema, can help to make sense of noisy empirical data and guide perception.

Chinn and Malhotra argue that conceptual change can be impeded because students with incorrect schema can fail to make correct observations. They suggest that supporting students to understand that observations can be biased may promote conceptual change but such change will require an extended period of teaching.

To summarise: when planning a demonstration, it is worth considering how your students' prior knowledge may influence how they interpret what they see in a demonstration and the aspects they focus on.

more...

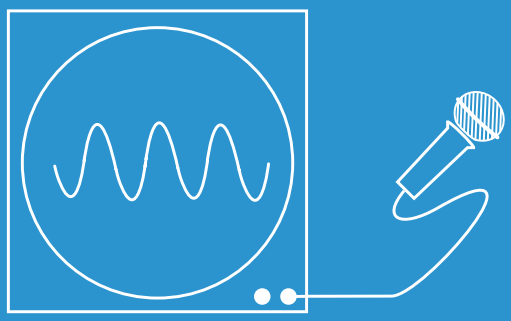
Michael Shermer's *The Believing Brain* is a good introduction to how humans make sense of the data they encounter.

Reference:
Chinn, C. A., & Malhotra, B. A. (2002). Children's responses to anomalous scientific data: How is conceptual change impeded?. Journal of Educational Psychology, 94(2), 327-343.

Pull out and keep!

Teaching sound waves

What's inside



Sounds confusing?

Sound is a topic that gives rise to many misconceptions. Our everyday language is littered with deceptive phrases like "the sound was carried on the air" and "listening to the radio". So when students get to secondary school, they are likely to have a confused idea of what a sound wave is.

Asking them to draw diagrams for situations where sound is involved can be revealing. Some will avoid using diagrams altogether; others will represent sound as a single entity, for example a line that travels from a source to a detector. Most will struggle to represent sound accurately.

Effective teaching strategies for 11-14 year olds include re-enforcing the source, medium and detector model, and using experiments where there is no obvious source of moving air (see Activity 1). As they progress, they learn about the longitudinal nature of the waves. However, many 14-16 year olds find it difficult to conceptualise this type of motion. The fact that an oscilloscope trace for a sound wave looks like a transverse wave only adds to their confusion.

A good teaching sequence for 14-16 year olds is to introduce waveforms using the slink-o-scope demonstration before exploring sounds using a real oscilloscope (Activity 2).

Other common misconceptions and suggestions on how to address them are shown in the adjacent table.

Misconception	How to address it	Try this
Sound can travel through empty space	**Demonstrations in which the air surrounding the sound source is removed**	· A bell in a bell-jar. · A buzzer in a vacuum coffee saver. The sound from the bell or buzzer gets quieter as the air is removed.
Sound is something that is carried by individual particles	**Class activities that explore sound travelling through solids**	· Cups and strings. · Listening by resting an ear on the desk whilst a neighbour delicately scratches the bench. Emphasise that the individual particles in a solid can't move from one end to the other.
Sound travels more slowly in a solid than a gas	**Models that show that a disturbance travels faster in denser materials**	· Use standing dominoes or Jenga blocks arranged in two rows. One row has the dominoes with twice the spacing of the other. When students knock over the starting domino, the disturbance will travel faster through the more densely packed dominos.

New quick practicals on IOPSpark

The class practical and demonstrations featured in this issue are part of our new collection on IOPSpark at **spark.iop.org/quick**

Ages 11-14

Activity 1: Dancing sprinkles

This class practical shows that a loud sound is capable of making grains jump. You can use it to introduce the idea that sound is a vibration of the air.

Equipment

Each group of students will need:

- Bowl
- Cling film
- Hundreds and thousands sprinkles of the type used for cake decorations
- Metal baking tray to make a loud noise
- Large metal spoon or drumstick

Instructions

Ask the students to:
1. Cover the top of the bowl with cling film. Stretch it tightly.
2. Shake some of the sprinkles onto the cling film.
3. Hold the baking tray close to – but not touching - the cling film and strike it sharply with the spoon.

Discussion

Ask students: "Why do you think the sprinkles move when they haven't been touched by anything?"

Highlight what is the source, medium and detector in this experiment (baking tray, air and cling film respectively) and introduce the idea that sound is a vibration of the air in your explanation.

When the metal sheet is struck it vibrates and these vibrations are transmitted through the air to the cling film. The sprinkles on the surface of the cling film help us to see its motion.

Extension idea

Students could investigate how changes in volume and pitch affect the motion of the sprinkles (see worksheet on page 12).

more...
spark.iop.org/dancing-sprinkles

Speedy phones

You can measure the speed of sound using two smartphones with the PhyPhox app. Watch the video at **bit.ly/PhyPhoxSound** and download the app at **phyphox.org**

Laptop oscilloscopes

There are a number of free software packages to turn a laptop into an oscilloscope. Download onto multiple laptops for class practicals. For example, Soundcard Oscilloscope, available from **zeitnitz.eu/scope**, allows you to pause the trace so that you can discuss key features.

Make 'em sing

Bring a bit of *The X Factor* into your classroom by combining oscilloscope activities with karaoke! As well as singing along to their favourite songs, you could challenge students to sing a single note. Alternatively, ask students to bring their musical instruments to provide a purely instrumental sound source.

Credit: Shutterstock

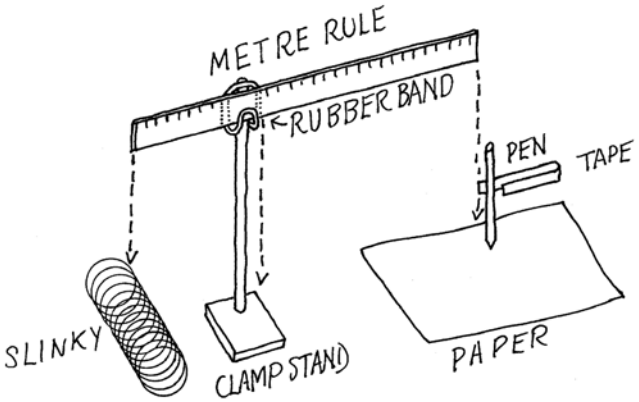
Ages 14-16

Activity 2: Slink-o-scope

This activity introduces sound wave traces on an oscilloscope using a mechanical analogue.

Equipment

- Slinky spring
- Metre rule
- Rubber band
- Clamp stand
- Felt tip pen
- Sticky tape
- Graph or squared paper



Preparation

Building and testing a slink-o-scope takes about 10 minutes. For instructions, see diagram above or watch the video at at **spark.iop.org/slink-o-scope**

Test your slink-o-scope by placing paper underneath the pen. When you send longitudinal waves down the slinky, the metre rule should pivot around the rod of the clamp and the pen should move up and down on the paper.

Demonstration procedure

1. Appoint an assistant to hold the paper under the pen.
2. Hold one end of the slinky in place and move the other back and forth to generate longitudinal waves. Show the result to the class – the pen should trace a straight line.
3. Now ask the assistant to move the paper at a steady speed in a straight line towards the clamp stand as you send waves down the slinky.
4. Display the resulting trace to the class – they should see a curve with a shape close to a sine wave.

Discussion

Ask students: "What labels should I add to the vertical and horizontal axes?"
Encourage them to think about what causes the motion of the pen across the paper. The up and down motion is driven by the slinky. The vertical axis shows the displacement of the coils. In the sideways direction, the paper was pushed at a steady speed. Emphasise that the horizontal axis shows time: the distance between two peaks is the time-period (not wavelength).

Then ask: "How would the graph change if I moved the coil back and forth by a greater amount? More quickly?"
If the coils move back and forth by a larger amount, ie you increase the amplitude of the waves, the size of the peaks will get bigger. If they move more quickly, ie you increase the frequency, the peaks on the graph will get closer together.

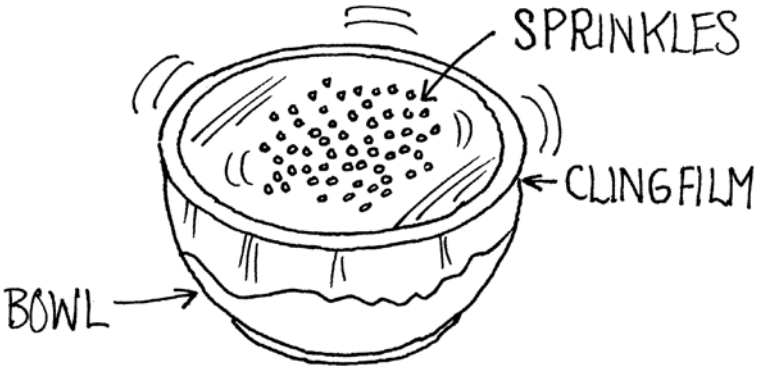
Slink-o-scope vs oscilloscope

Change in oscilloscope setting	Slink-o-scope model
Turn time base on	Move paper at steady speed
Increase time base setting	Increase speed of the paper to new steady speed
Increase vertical sensitivity setting	Increase pen to pivot distance

more...
For a teachers' introduction to the controls on an oscilloscope see **bit.ly/IOPoscilloscope**

Student sheet

More dancing sprinkles



What to do:

1. Shout at the sprinkles going from a loud to quiet voice (ie change volume).
2. Shout "boo" in a deep voice and "me" in a high voice (ie change pitch).
3. Record your observations below.

		Effect on sprinkles	
Volume of shouting (high/low)	**Pitch of shouting (high/low)**	**Height of movement (higher/lower)**	**Speed of movement (faster/slower)**

4. Complete the following sentences using these words (some more than once, some not at all):

waves · air · amplitude · frequency · vibrate · backwards · forwards · lower · higher · faster

When you make an object vibrate, this motion is passed on to the _____ surrounding the object.

The molecules which make up the air _____ and hit other air molecules. This creates sound _____ that travel through the air.

The sound waves strike the cling film and cause it to _____ , which causes the sprinkles to move.

When you shout, the difference in high and low sounds is caused by variations in in the sound wave you produce:

A higher _____ is due to air waves fluctuating more rapidly and the sprinkles bounce up and down _____ . With fewer fluctuations per second the pitch is lower and the sprinkles bounce up and down more slowly.

The _____ of the sound determines how loud it is. With louder shouting, the sprinkles jump _____ .

Stories from physics

Sound: ears, guns and Bell

The pinna notch

The pinna (or auricle) is the visible part of the ear and is made of cartilage. It amplifies incoming sounds-frequencies between 2 kHz and 7 kHz are amplified with a peak gain of around 12 dB. However, the amplification is not uniform across all frequencies. The complex shape of the auricle means that sound waves travel along a number of paths to reach the ear drum. Destructive interference between waves that have travelled along different paths results in a selective attenuation or reduction of frequencies between 6-16 kHz. This range of attenuated pitches is called the pinna notch and the frequency range it occurs at shifts as the elevation angle of a source of sound varies. It is thought we use the pinna notch as a clue to determine the elevation of a sound.

Bell's ear machine

Alexander Graham Bell's fascination with sound and human hearing may have been inspired by his mother's and wife's deafness. With Boston audiologist Clarence J. Blake, Bell improved the design of phonautographs, devices for producing visual representations of sound. Bell had the idea that replicating the structure of the human ear would produce a better recording device. Blake was inspired and proposed using a human ear as part of the device and he obtained one through his contacts at Harvard Medical School. They connected the bones in the ear to a straw that traced patterns on a sheet of glass covered in soot from an oil lamp. Bell later reported that his work on the phonautograph led to his insight that if a thin ear membrane could control the movement of bones, a paper membrane might be used to vibrate a piece of iron, setting the ground for his invention of the telephone. In 2016, a curator at the Canada Science and Technology Museum, constructed a replica of Blake and Bell's phonautograph.

The startling starting gun

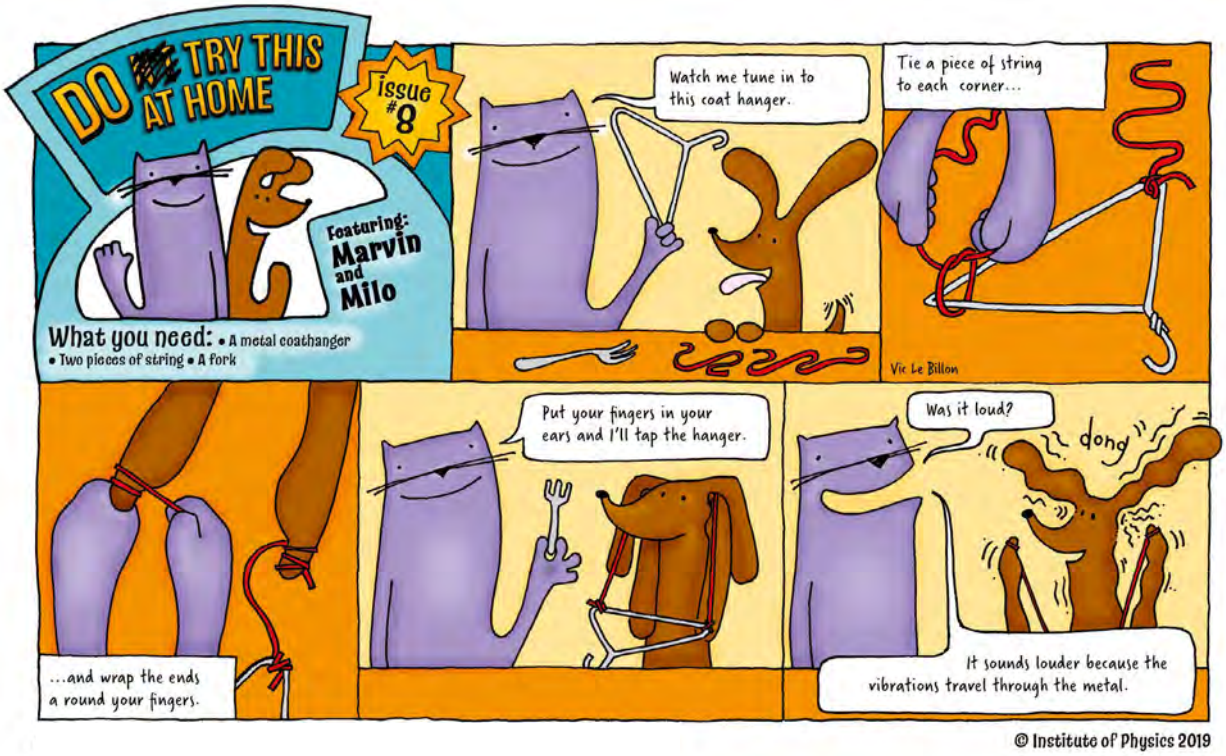
Researchers have discovered that the starting gun technology used in athletics gives an advantage to runners in the inside lanes. Many athletics events use a silent starting gun that triggers a start tone from speakers positioned behind the runners' blocks. But, at the Olympics, a traditional gun is still used. Analysis of data suggests that runners in lane 8 leave the blocks, on average, 150 milliseconds before athletes in lane 1. This can make a difference of around 1 m at the finishing line. The difference in performance is not just related to the speed of sound. Those closest to the gun may also benefit as reaction time appears to be inversely proportional to the 'go' signal intensity. Noises loud enough to provoke a startle response decrease reaction time and increase the peak motor force exerted.

more...

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

Musical coat hanger

Marvin and Milo cartoons can be downloaded at **spark.iop.org/collections/marvin-and-milo**



Physicseducation

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 (opposite page).

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

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.

Sounding off and lighting up

It is quite difficult to think of convincing demonstrations which show that sounds travelling through the medium of air are acting like a wave, especially with younger students. So a good starting point for teaching waves is the source-medium-detector model as outlined by Ian Lawrence.

Using this model allows the teacher to explain the entire journey. For example, play a video of a guitar string in slow motion so they can see the oscillation of the source. Similarly, show a slowed-down oscillation in a detector, such as the diaphragm moving in a microphone.

So if the journey starts and finishes with an oscillation, it is not too great a jump to expect the journey through the medium to be made up of a series of oscillations - which constitute a sound wave. Part of the reason why it is difficult to show sounds travelling through a medium is that our ears are really very good at hearing - we can detect very small changes, in fact pressure variations of less than one billionth of atmospheric pressure.

more...

bit.ly/PEsounding

My favourite demonstration

If you want an amazing demonstration of a source of sound in action then top of the list has got to be the *Singing Rod*. It is not difficult to understand why the author of this paper, Paul Gluck, described this as his favourite demonstration. You can demonstrate the difference between longitudinal and transverse waves, fundamental and harmonics, nodes and antinodes, interference and the Doppler effect – all you need is one aluminium rod, which could be from a clamp stand, and some rosin, as used by ballet dancers and fiddlers, and a small hammer.

more...

Read Paul's paper at **bit.ly/PEsingingrod**

See Gary's demonstration on YouTube at **bit.ly/YTsingingrod**

Musical instruments, throat singing and wine glasses

There are two authors particularly worth looking out for when searching the pages of *Physics Education* for papers relating to the teaching of sound. Between them they have written enough for an entire issue or more of music related papers!

Michael C LoPresto, a trombone-playing singer and teacher of physics, has written many papers over the years, from *A theoretical Trombone* to *Hearing the music in the spectrum of hydrogen*. Michael J Ruiz is professor of physics at the University of North Carolina. His papers include *Tuvan throat singing and harmonics*, *Fun with singing wine glasses* and *The monster sound pipe*.

more...

Search for LoPresto or Michael J Ruiz on **iopscience.iop.org**

Credit: Physics Education

The monster sound pipe: the keyboard is used to match the frequency when the tube is smacked. The matched tone is found to be a semitone lower than the theoretical predicted value.

Developing critical analysis of explanations in physics teachers: which direction to take?

This is a stand-out paper. French physicist Laurence Viennot describes the direction she thinks we should be moving in when it comes to teaching physics: away from rote learning and towards more critical thinking.

She says: "Although it is hard to accept, there are many examples of 'teaching rituals'—that is, contestable explanations that are both very common and undiscussed. These include the idea that a hot air balloon can stay at a stable altitude with the same pressure everywhere around the envelope and inside." [In fact, balloons stay stable at altitudes because of the pressure gradients inside and outside the balloon's canopy.]

She describes what critical analysis is, then looks at the obstacles to it for teachers, how to help them critically analyse explanatory texts and quality-diagnose these texts. The skills outlined in the paper are of plenty of use outside of physics, and being critical of explanations in textbooks and online allows teachers to bring a critical eye to their own explanations.

She concludes: "Focusing students and teachers on their responsibility to actively accept or reject received explanations would also help to enhance their self-confidence."

more...
bit.ly/PEDcritic

Credit: Shutterstock

Common explanations should be analysed: can hot air balloons stay at a stable altitude with the same pressure everywhere around the envelope and inside?

Determining Planck's constant with LEDs. What could possibly go wrong?

Credit: Physics Education

A series of stills from a video showing the LED behaviour as the voltage across them is increased.

If you do the standard Planck's constant practical with LEDs then you need to read this paper by physicists and physics educationalists Dean Zollman and Ian Bearden. I was under the impression that I had a reasonable grasp on how this practical worked. I knew that you cannot use just any old selection of different colour LEDs and I knew about looking at the LEDs by looking down a cylinder of black paper to make sure you see the point where the light is just triggered.

But the choice of LEDs turns out to be critical. The authors write: "For some LEDs, the energy of the light emitted from the LED can be quite different from the gap energy. If these LEDs are used for the experiment, the results will give different results for Planck's constant."

more...
bit.ly/PEDleds

More recent articles

The giant, the wintermaker, and the hunter: contextual ethnoastronomy towards cultivating empathy **bit.ly/PEDgiant**

What makes a good physics teacher? Views from the English stakeholder community **bit.ly/PEDgoodteacher**

Is it simple to explain simple experiments? The 'heavy newspaper' stick break **bit.ly/PEDsimple**

Catastrophic cancellation in elastic collision lab experiments **bit.ly/PEDcatastrophic**

Measuring a spring constant using an optical spring-mass system and a solar panel **bit.ly/PEDalgebraic**

Once more about the Cartesian diver **bit.ly/PEDdiver2**

What happens next?

Credit: Physics Education

What happens when two similar balloons with different inflations are connected by a tube. Is it possible to blow up two balloons simultaneously using a 'Y' connection?

more...
bit.ly/PEDwhatballoon

talkphysics

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

Sound as an ambiguous term

In 2018, teacher supporter Jon wrote: "I've been thinking for a while about how many ambiguous terms we encounter in physics at the 11-14 level. I'm used to plenty of words we encounter in everyday life, which then have a specific meaning in physics (energy, power, etc), however I'm more interested in the terms that seem to have multiple meanings even within physics, or where their everyday use is sometimes used in physics or physics teaching.

"Right now I'm intrigued by 'sound'. I think we sometimes mean specifically a wave that humans can hear, but other times we use it as an umbrella term for all similar waves – infrasound, 'sound' and ultrasound. The analogy is light, where sometimes we're using it to mean electromagnetic waves (eg the Diamond "Light" Source) and other times we specifically mean an electromagnetic wave we can see. For light, I think we're offered clear physics terminology that we can choose to use to distinguish between these – do I mean any electromagnetic wave, or do I specifically mean the light that humans can see? Is anyone aware of similar terminology we can use for sound?"

more...
Follow the discussion at
bit.ly/TPambiguous

physicsworld

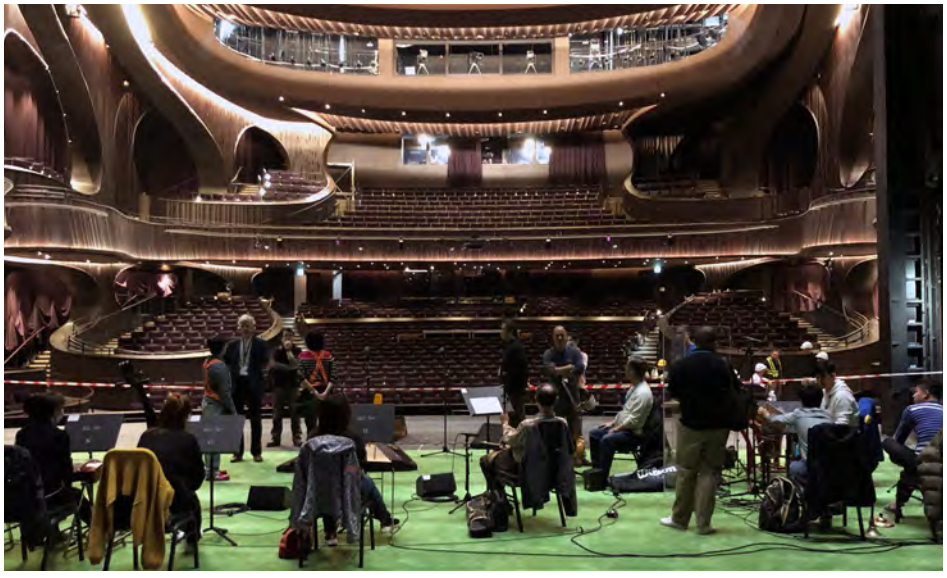
Stories from our magazine for the global physics community. Visit **physicsworld.com**

Sound designs

The refurbishment of public buildings is often more than meets the eye. Anna Demming speaks to acousticians and architects about the acoustic considerations behind their designs for public spaces and some of the tricks to tackle the conflicting demands on these venues.

For example, the Xiqu Centre in Hong Kong, which opened in 2019, must cater not only for amplified and non-amplified Western music but various traditions of Chinese operas from Beijing, Shanghai, Guangdong and Hong Kong as well. Optimising this space meant providing the means to balance the sound of the singers with respect to the orchestra, and to emulate the open-air acoustics these traditions were fostered on. The auditorium was designed with complex shapes, gaps and insulation to absorb or scatter sound, including motorised curtains that can be adjusted as needed.

more...
Read the full article at
physicsworld.com/a/acoustics-in-architecture



Credit: Sound Space Vision

The Xiqu Centre in Hong Kong has unusual acoustic demands.

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

How live drawing boosts students' learning

The idea that working memory is restricted – if too much material enters the working memory, it doesn't all fit and learning doesn't occur – isn't new. But this model is an oversimplification.

Cognitive scientists believe that working memory is split into two parts: the phonological loop which deals with language, and the visuo-spatial sketchpad which deals with images. Both components are limited to a number of items and work as separate channels, effectively doubling the overall number of items that can be held in the working memory.

When learning, you benefit from access to both visual and verbal memory, which is where dual coding comes in. Dual coding uses language and images simultaneously, and you can use it to great effect in the science classroom with this live drawing approach:

1. Start with a blank canvas (ie an empty board).
2. Start drawing the diagram, explaining aloud as you go.
3. Then add your label to the diagram silently.
4. Allow students to read it.
5. Bring your students' attention back to you, and start drawing the next section.
6. Explicitly gesture and point to the bits you want students to look at while you are explaining eg by saying 'look at this'.
7. Repeat the cycle until your diagram is complete.

You can also use dual coding to illustrate how the content is organised and how different components relate to each other. However, a random image on a slide isn't going to help students with dual coding unless it is directly tied to the material. You have to keep your students' attention fixed on the flow of your explanation.

In short, use a visual representation to support your verbal explanations as often as you can. Avoid crowding your students' working memories and be sure to direct their attention to where it needs to be.

more...
By Adam Boxer, head of science at The Totteridge Academy, London.
Full article at **rsc.li/3aqxnFJ**

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**

New advice on radioactive materials

We recently uploaded a new version of *L93: Managing Ionising Radiations and Radioactive Substances in Schools and Colleges* (dated November 2019). Ensure any old paper copies are suitably recycled. Details of the update can be found on CLEAPSS's website – search for document GL114.

We also clarified our guidance on the grout/dustbin route for the disposal of sealed sources. Search our website for GL220 for the updated guidance – this applies to, for example, old Cobalt-60 sources or Radium paint diffusion cloud chamber sources.

Want to know the difference between a RPA and RPO?

Following a deluge of routine helpline calls with respect to the area of practical radioactivity, we have developed a Frequently Asked Questions. So if you want to know the answer to this question, search for GL334 on **science.cleapss.org.uk**

CLEAPSS, the physics teacher's best friend

We were recently interviewed on the Physics Teaching Podcast, run by seasoned physics teachers Robin and Thomas. The podcasts address their experiences teaching, misconceptions in physics, teaching ideas and, most importantly to us, practical work. Samir from CLEAPSS spoke about practical work in physics, notably the vacuum ping-pong cannon and Arduino, the role of CLEAPSS in practical science, and how CLEAPSS is pronounced!

Search for CLEAPSS on the **physicsteachingpodcast.com**

Register now for two free opportunities for schools

Bring your students to the Summer Science Exhibition
Aimed at students in years 10-13 who are aspiring to study science or mathematics further, visits provide an opportunity to explore the future of science and meet researchers, finding out about the skills and approaches being used to solve 21 real world issues. Attend either a fixed two-hour slot or a full-day programme.

Details and booking links:
royalsociety.org/schools-booking

Help judge the Young People's Book Prize
Schools, with their students, are invited to apply to be a judging panel for the Young People's Book Prize 2020. Successful schools receive a free set of the six shortlisted books, plus a set of judging materials to guide your group in choosing a winner. In November, results from panels across the UK will be combined to decide the ultimate winner.

sciencebooks@royalsociety.org

THE ROYAL SOCIETY

Cavendish Laboratory Physics Outreach

The Cambridge Physics Experience is a free one-day event organised by the Cavendish in collaboration with many Cambridge colleges.

This one-day programme consists of:
· a Cambridge college tour
· information and advice about Higher Education and applying to Cambridge at the Cavendish Laboratory
· an afternoon of practical physics and curriculum physics problem solving.

CPE events aim to increase participation in physics by all and to challenge misconceptions about physics and Cambridge University.

Bursaries are available for travel and lesson cover for schools in certain areas.

Suitable for years 7 upwards. Schools welcome from throughout the UK. Dates available in 2020 and 2021. For more information, please visit **outreach.phy.cam.ac.uk/cpe**

Exploring the International Space Station

AR Adventure in Space is a free mobile game application available from the App Store and Play Store. Players explore the International Space Station, role-playing as an intern alongside British ESA astronaut Tim Peake.

Features of the app include:

· float inside the station with a 360° view, watch videos narrated by astronauts and learn about apparatus use for living in space

· ask Tim questions about going on a spacewalk, having a cuppa in space and much more

· mini games: try to eat and drink in space or capture cargo using the Canadarm

· career quiz about space careers on and off Earth.

Created by Octagon Studio in collaboration with Venture Thinking for the UK Space Agency Space For All programme.

UK SPACE AGENCY

Credit: Marc Quinn Studio

World's largest space dedicated to the story of medicine

Newly opened at the Science Museum, Medicine: The Wellcome Galleries spans centuries and continents. More than 3,000 objects reveal how ideas about health have changed throughout history.

Arranged around five themes – Medicine and Bodies, Exploring Medicine, Medicine and Treatments, Medicine and Communities and Faith, Hope and Fear – the displays are free to visit. They are an unparalleled resource for secondary students, linking to science, history, psychology, PSHE and religious studies.

If your school can't visit, access the collection using our free interactive resource featuring digital 3D scans of key objects. Students can explore the objects from every angle, learning how they were used and discovering how lives have been transformed by changes in medicine and healthcare.

sciencemuseum.org.uk/learning/medicine-wellcome-galleries-school-info

SCIENCE MUSEUM

Got a physics NQT starting this September?

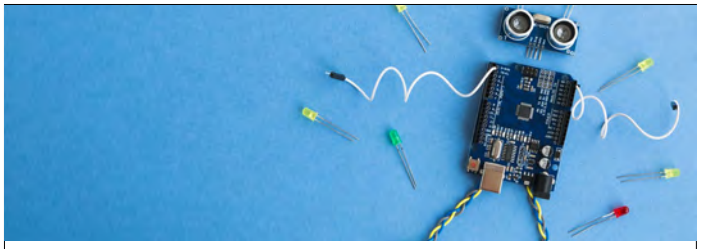
If so, you could be eligible to be part of a major national trial being run by the IOP. And you would receive £250 for your science department.

With only 547 physics teachers in ITT this year, we need to understand how to encourage as many as possible to enter and stay in the profession.

The KEEP Teaching trial is part of the IOP's work in this area. We're looking for 120 schools with physics teachers starting their NQT year this September. Could your school be one of them?

Schools and trainees can register interest **iop.org/keeptrial** and we'll send you more details.

IOP Institute of Physics



School Grants Scheme – what could you do with £600?

Over a quarter of a million students have already benefited from our School Grants scheme – thank you for these innovative and engaging projects!

And we are looking forward to the next set of proposals. The closing date for applications for autumn term ideas is 1 June:

- grants of £600 are available for projects, events and activities promoting physics and engineering
- we're particularly keen on promoting: particle physics, astronomy, space and nuclear physics, energy, transport, information and communications, design and promotion and the built environment
- open to schools, colleges or home school groups based in the UK and Ireland

The scheme is run jointly by the Institute of Physics, Institution of Engineering & Technology and the Science & Technology Facilities Council.

iop.org/schoolgrants
#IOPSchoolGrants

Science & Technology Facilities Council IET The Institution of Engineering and Technology IOP Institute of Physics

Super Physics - Calling able year 9 students!

Join one of our fast-paced days of practical physics with opportunities to practise communicating physics for teams of four. Your students will enjoy an illustrated lecture to inspire plus certificates, prizes and trophies.

Tuesday 30 June
STEM Innovation Campus, Bury St Edmunds, Suffolk, IP33 3TB
Details and registration: contact **Roger Rande rra-de@burytrust.org**

Friday 3 July
Uppingham Community College, Rutland, LE15 9TJ
Details and registration: contact Helen Pollard **helen@pollardweb.me.uk**

There is no cost to participating schools but booking is essential. Accompanying teachers will be asked to assist with marking.

Please note that costs (excluding cover and travel) are met by IOP, the Ogden Trust and hosts, with thanks.

The Ogden Trust
making physics matter

IOP Institute of Physics

CHARTERHOUSE

PHYSICS
SUBJECT KNOWLEDGE ENHANCEMENT COURSE 2020

A free two-week residential course aimed at boosting physics subject knowledge

Week 1: Monday 29 June to Friday 3 July
Week 2: Monday 6 July to Friday 10 July

Experienced teachers deliver talks and supervised laboratory work covering the basics of Key Stage 4 and 5. Delegates have an opportunity to meet recently qualified teachers during the evening sessions.

CHARTERHOUSE SCIENCE DEPARTMENT

Telephone: 01483 291618
Email: science@charterhouse.org.uk
Application closing date: Monday 1 June 2020

Registered Charity 312054

Find a CPD event near you

Credit: IOP

IOP coach Niloufar Wejtunge demonstrates Newton's 3rd law with an electronically controlled car on top of cards on pencils at the IOP South Regional Day in November.

Canterbury Regional Day

7 March | 10:15am - 4:15pm
St Anselms RC School,
Canterbury, CT1 3EN

Register at
bit.ly/IOPcant20

South Regional CPD Day

27 March | 9am - 4pm
Clifton College, Bristol
BS8 3JH

Contact
bit.ly/IOPclifton20

Physics of rock climbing

4 April | 12:30pm – 4pm
The Warehouse Climbing
Centre, Gloucester GL1 1HY

Register at
talkphysics.org/events/physics-of-rock-climbing-2

North Wales Physics Teachers' Conference/Cynhadledd Athrawon Ffiseg Gogledd Cymru

July (date tbc)
Bangor University

Contact
a.clowser@johnbright.uk

Making physics GCSE required practical work easy

20 April | 5pm - 7pm
Truro College,
Truro, TR1 3XX

Register at
bit.ly/IOPgcsetruro

46th Stirling Physics Teachers' Meeting

6 May | 10am - 4pm
Stirling Court Hotel,
Stirling FK9 4LA

Contact
stirlingmeeting.org

Technicians' meeting and workshop

11 June | 10am - 12 noon
Uppingham Community College,
LE15 9TJ

Contact
helen@pollardweb.me.uk

Teacher CPD: Gravity and Relativity

19 June | All day
University of Lancaster,
Physics Department,
LA1 4YB

Register at
bit.ly/IOPgravitycpd

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

All events listed are funded by the IOP and free to attend unless otherwise stated.
All teachers of physics are welcome, whether or not you consider yourself a physicist!

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

Scotland
Stuart Farmer
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Ireland
Lucy Kinghan
lucy.kinghan@iop.org

Wales
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Midlands
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South
Trevor Plant
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For support running CPD, contact our Professional Practice Group

education-ppg@iop.org

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